JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVII. MAY, 1889. NO. 5.

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The first improvement consisted in the substitution of an elastic artificial foot, made of india-rubber, without any joints whatever, for the artificial foot, previously made of wood, with joints to permit motion of the ankle and toes, and also an artificial hand made of india-rubber, simulating the missing member. As a matter of course, such an artificial hand, which is here illustrated, could do little else than

had solidified.

FIG. 3.—Ingot placed on its side before interior steel had solidified.

remain on end until cold.

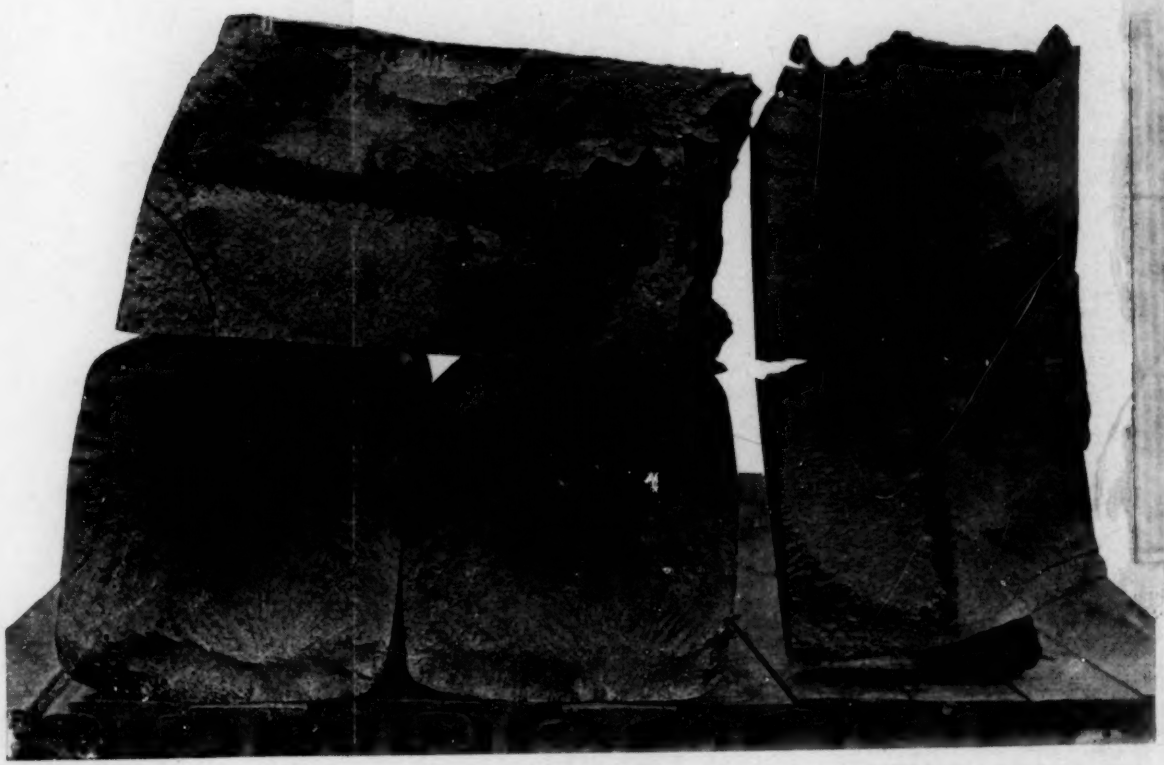

FIG. 4.—Ingot from same conversion as *Fig. 3*, but allowed to remain on end until cold.

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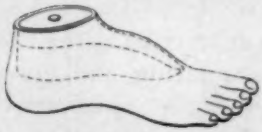
restore appearances; it had, beside this, the merit of not wearing out gloves and other apparel as rapidly as its wooden and metallic articulated predecessors, and it was much less costly and not so unpleasant, when it came into personal contact. The rubber foot, which is also here illustrated, consisted of a wooden block rigidly secured or formed with the leg and extending downwardly to within about two-fifths of the distance from the ankle to the sole, and forward to nearly the first articulation of the meta-

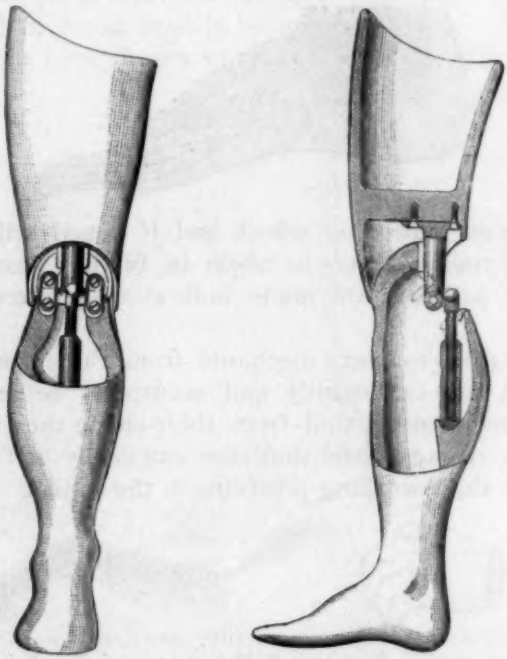
tarsus and toes; this block was covered with india-rubber, and all the rest of the foot, from heel to toes, was formed of elastic vulcanized rubber.

The action of such an artificial foot was that of an elastic segment of a wheel. The shock of placing the weight upon the heel at each step was avoided by the elastic cushion of rubber forming the heel, and as the weight was progressively transmitted to the forward part of the foot, by the combined effect of muscular exertion in the remaining part of



the natural limb to which it was applied, and the momentum previously acquired, an easy flexure of the toes took place, which, reacting elastically as the weight was transferred to the other limb, assisted in the flexure of the knee joint, giving an easy and naturally appearing movement. Such artificial feet were, upon trial by those who were maimed and had used other artificial substitutes, found to be easier to use, lighter and more comfortable. They were rapidly introduced into use, and have proved from their greater simplicity more durable and far less destructive to clothing.

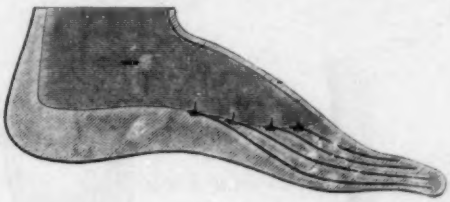
The next improvement (the picture of which is here shown) is an improved and simplified construction of the knee joint of artificial limbs, made with a view to strength, facility of accurate manufacture and easy application. This joint consists of a flanged plate, secured by screws to the under surface of the thigh socket, and has formed, integrally with it, of steel, by drop forging, a cylindrical pillar, terminating in two lateral journals having the same axis, resembling an inverted capital letter T.



These journals perform the function of the condyles of the femur, in the natural limb, and are fitted accurately in bearings formed with oblique caps, secured by screws in the rear of the knee portion of the leg.

On the rear of the pillar, in about the same horizontal plane as the axis of the journal when the limb is extended and erect, is formed a short lever, having a spherical end, against which a cup, formed upon the upper end of a

sliding plunger, is pressed upwardly by a spring in a guiding cylindrical case, having a hemispherical lower end resting in a correspondingly shaped cup or cavity in a shoulder in the interior of the calf portion of the leg. When the limb is extended, the spring operates with full effect, in holding the limb extended; as it is flexed the lever gradually assumes a greater angle to the line of reaction of the spring and cup, so that, when it is flexed with the thigh at right angles with the leg, the



spring has no motion or effect, and if flexed still further, the spring then operates to assist in further flexure. The pillar and journals are made hollow, so as to reduce their weight.

It is obvious to every mechanic from the form of these parts, that they can readily and accurately be finished by drilling and turning, that from their shape they must possess great strength, and that they can easily be fitted accurately into their working positions in the limbs.

Another useful feature of this form of joint is, that the upper part of the pillar forms an effective stop, to arrest the forward motion of the thigh upon the leg during extension, by coming in contact with a cushioned cavity in the rear of the knee; this point of support being at a considerable distance from the axis of the knee joint, avoids any severe strain and shock from the sudden extension of the limb, which in other constructions, having the stops made in plates at the sides of the joint, are necessarily close

to the axis of motion, and consequently are subjected to a greatly increased strain.

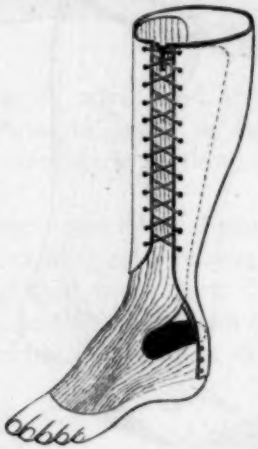
This concussion of the stop is found to be a frequent cause of breaking, both of the stops and joints of other forms of limbs, and has had a great deal of ingenuity expended upon it to avoid it, by providing check straps or cords, reaching from the thigh to the leg, and designed to stretch tight before contact of the stops occurs. These cords required greater care to keep adjusted to the proper tension than could readily be given to them. The simple contrivance, here shown, obviates the entire difficulty.

The axis of the knee joint is placed near the back of the limb, so that the weight of the wearer ensures a firm support on the limb when extended, and at the same time slight exertion suffices to move the limb in stepping forward.

The shell or parts, which in form imitate the natural limb, are made of light willow or basswood, as thin as is consistent with strength in the lower part, and in the upper part excavated to fit the remaining portion of the natural limb; these are covered tightly with parchment and painted and varnished to resemble the complexion of the natural skin.

The continued use of the limbs thus constructed demonstrated that the front portion of the foot was too easily flexible, or rather that greater elastic force was desirable, and this requirement was met by the inventor by a device in which a textile fabric was introduced between the lamina of india-rubber forming the ball and toe portion of the foot, as here shown in the drawing.

The desire to adapt the india-rubber hands to changes of flexure, for purposes of better and more natural appearance and to grasp light objects, led Mr. Marks to improve them by making a light wooden core in the palm or metacarpal portion of the hand and inserting ductile or flexible metallic



wires in such core, which extended centrally through the fingers. By bending the fingers they retain the form in which they are set. The test of several years' use of these last-named improvements has proved their utility.

The latest improvement in artificial limbs consists in forming the leg and foot part of a single piece of wood, having the grain curved naturally in its growth, such pieces being procured from the parts of the trunk contiguous to the roots and branches of trees; limbs made in this way are stronger with the same amount of wood remaining in them, than when made of parts and glued together, and are made water-proof, which is a specially valuable feature

when the occupation of the wearer exposes it to constant dampness, or to water itself, as in fishing, mining, dredging, etc.

By making limbs in this manner from natural curves in the growth of the wood, it has become practicable to make light and substantial artificial feet, adapted to partial amputations of the foot. Such appliances are shown herewith, and have been used with unprecedented satisfaction where articulated feet were clearly impossibilities.

The advantages derived from lightness of such artificial substitutes, will readily be apparent, when the resistance to motion from inertia is considered. The ankle and foot and

lower part of the limb being light and hollow, move easily and promptly with but little exertion from the remaining part of the natural limb, and the comfort and ease of the wearer are thereby greatly promoted.

With the specimens of limbs are submitted well-perfected adjuncts in the way of suspender straps and girdles, and great ingenuity and skill have been displayed by these inventors, in adapting limbs to specific cases which, whilst useful and light and highly commendable, cannot be particularized in this report.

The FRANKLIN INSTITUTE has not made any examination in this department of the arts since January 11, 1849, when,

as appears on page 61, Vol. xlix, of the JOURNAL, they reported upon the merits of the Palmer artificial limbs. Since this time about sixty or more patents have been granted for alleged improvements in artificial limbs, nearly all of which, except these, which are the subject of this report, added complications or additional parts to the limbs. In none of these inventions does there appear such desirable simplicity of construction and reduction of cost of production as in those under consideration. The makers are enabled to make most durable and substantial workmanship of all parts, and have demonstrated all of these points by making something over 9,000, which are in constant and satisfactory use.

The extreme simplicity of construction has proved the means of bringing their cost within the reach of many persons requiring such appliances, who could not otherwise afford to use and maintain them, and there are now many persons using them and actively competing with others in many lines of industry: among them, machinists, blacksmiths, farmers, fishermen, carpenters, moulders, instrument makers, railway conductors, engineers, and, in fact, representatives of nearly every handicraft.

Mr. Thomas Kehr, a skilled workman in all branches of their manufacture, who works daily at the bench, standing upon two of them, demonstrated publicly at the INSTITUTE meeting their facility of use and value in walking, better than anything that can be said upon the subject. (One of Mr. Kehr's legs was amputated in the middle of the femur and the other an inch and one-half below the patella.)

[The report of which the foregoing is an extract, and which embraced the recommendation of the award of the John Scott Legacy Premium and Medal, was signed by S. Lloyd Wiegand (*Chm.*), L. L. Cheney and N. H. Edgerton, and approved and adopted by the Committee on Science and the Arts, at its stated meeting, held Wednesday, February 6, 1889.]

AMATEUR PHOTOGRAPHY IN ITS EDUCATIONAL RELATIONS.

By Prof. Charles F. Himes.

[*A lecture delivered before the* Franklin Institute, *February 11, 1889.*]

The Lecturer was introduced by the Secretary of the Institute, and spoke as follows:

Members of the Institute, Ladies and Gentlemen:

The subject as announced for the lecture this evening is Amateur Photography. Now, whilst many photographic societies experience great difficulty in defining satisfactorily the term Amateur Photographer, I apprehend that we will have little difficulty in agreeing in regard to the term Amateur Photography, and I desire at the outset that there may be no misunderstanding about it. The first mentioned difficulty originates in the two-fold character, possessed by many who practice photography. They have an amateur and a professional side, and frequently in the professional the amateur side is so unduly developed that the professional is almost lost sight of, whilst, on the other hand, in some amateurs the development of professional traits is only restrained by the quality of their work. By amateur photography then this evening we mean amateur practice, whether by professional or non-professional.

In determining upon the treatment of the subject I have been influenced by a knowledge of the fact that this Institute is deeply interested in the encouragement of popular scientific education, and healthy public sentiment upon this point, as well as in higher scientific investigation. A few years ago, in the course of lectures at the International Electrical Exhibition, under your auspices, I had the pleasure, in a lecture on Actinism, to illustrate the scientific basis of photographic practice, and to call attention to some of the most recent advances, of which orthochromatic photography was

then, perhaps, the most recent, for the further development of which this INSTITUTE has done so much through the contributions of Mr. Ives. This evening I propose to call attention to and emphasize as best I can some of the more purely educational features of photographic practice, the resources of which in this respect have more particularly impressed me in connection with instruction for many years of classes in a course of so-called liberal education, I mean an ordinary college course, as distinguished from a technical course. I cannot but recognize, too, as a fact that amateur photography has perhaps reached its highest development in this city, and that its societies here are not only of the oldest, but among the most active and progressive, and that consequently it would hardly repay to consume time in demonstrating well-known processes. Any purely practical suggestions therefore, as to formulæ, wrinkles and dodges, will be purely incidental.

Amateur photography is sometimes called, and perhaps oftener looked upon, as a popular craze, as the fashionable amusement or pastime, as something that will have its day and in turn be supplanted in popular favor. The advertising columns of periodicals of current literature would tend to confirm such an impression. This treatment of amateur photography as a popular craze has a tendency to depress its practice to a lower level, and to check temporarily its inevitable permanent growth. But a closer consideration of this pastime, of its nature, its relation to permanent desiderata—not of a strictly commercial or technical character—will discover elements of permanence that distinguish it from the thousand and one other ephemeral minor arts that appear upon the surface of society for awhile and then lapse into merited or unmerited desuetude. As one who has employed photography, not only for recreation and entertainment, but for the higher uses of which it is susceptible, for research and as an educational means, I feel that in this place it will be proper and perhaps profitable so to discuss the subject that all who claim a high ideal for the art science may be strengthened in their advocacy and practice.

Now, nothing perhaps will show more clearly the permanent character of amateur photography than a brief glance at its history among us. There is something in it that stamps it as essentially different from the other arts alluded to. As an amateur of thirty years' experience, as a constant reader of its literature, as one enjoying each advance, each new application, and the rapid growth of photography as an amateur art, I see no backward step, no halt, no diminution of numbers or of devotion, but a steady forward movement along all lines, sometimes rapid, at other times slow, but always an advance. But the amateur of thirty years ago required many virtues in a high degree now scarcely known. At this point I miss much the inspiration as well as the moral support of the expected presence of your honored president, unavoidably absent to-night, to whom I could appeal to substantiate much that I may say. To him I owe my trend, or inspiration, if you please, in this direction. He had experimented with a process nearly related to one that to-day produces perhaps more square yards or miles of photographic prints, than all others together. I well remember the pleasure and surprise occasioned by the exhibition of a few of his early blue prints of ferns, accompanied by the statement that they were photographs, and after the statement of the simple process by which they were produced I was fixed as an amateur photographer. Everything at all available was soon printed in blue—leaves, ferns, laces, MSS., even old ambrotypes, scraped clean of their black varnish. The process, I said, was nearly related to the present blue process, but, like all other processes of that day, it was slow, exceedingly slow by comparison. The preparation of the paper consisted in simply brushing over it, lightly, back and forth, with a tuft of cotton, a solution of ferricyanide of potassium of a strength of about 100 grains to the ounce of water, the paper being pinned to a board at the corners. That paper can be exposed for hours, or even days, without danger of overprinting. It was so slow that many lost faith in it. After I had published the formula, more than twenty years ago, in *Leaf-Prints or Photography without a Camera*, with a

recommendation of it to beginners on account of its simplicity, I received many inquiries and complaints from all directions, and among them one through the publishers from Constant Guillou, whom all older amateurs will remember, and whom I remember well by his exquisite Cuban views received from him as a member of the first Amateur Photographic Exchange Club. His opinion in regard to the process was very pronounced, whether he named it a mistake or a fraud, I do not recollect. I can only account for the roundabout way in which his opinion reached me, by a failure on his part to recognize on the title page the name of one of his photographic correspondents. There was one effective answer to all these communications —a print produced by the process, and advice to give them time enough. The process is not without its good points. Some of the failures with it were due to want of discrimination on the part of the druggist, to whom early amateurs were most likely to go, between ferricyanide and ferrocyanide of potassium.

But it was not in the nature of things that one should remain contentedly simply a photographic printer, if there was even a remote possibility that images in the camera could be produced. To be sure, photographic cameras were not temptingly displayed much in the windows or pictured in advertisements. They were at best rather crude and decidedly expensive. But here again, my friend, your president, moved a little in advance. He made his camera, furnished with a spectacle lens. It was primitive enough, but it had one great virtue—it was at least light-tight. As to the negative process employed, it was one that I would hesitate to attack to-day with certainty of success. It was dry, of course, and was called Whipple's Albumen Process, a French process, improved by the addition of honey or syrup to the albumen, the vehicle of the alkaline bromide converted into sensitive silver bromide in the nitrate of silver bath. After sensitizing, the plates were washed and dried. Many things were learned, not strictly photographic. We learned to break eggs with a smart tap, so as not to affect the yelks, to hook out the germs with a toothpick, beat them to a perfect

froth without a patent egg-beater. We studied well the interminable list of "don'ts" and "take cares," acquired a proper dread of dust, which we were told was the greatest enemy of successful photography. We followed the book in all its multitudinous and minute details, in the cleaning of the plates, the levelling, the coating, the washing, the drying, and the storing of the finished plates—for we were groping around in an unknown field in helpless and almost hopeless darkness, and we held on to the leading-strings. But the book by Geo. W. Coale, though quite small and unpretentious, was a full one, carefully prepared, embodying much experience. There was not much left to be read between the lines. I cannot now ascribe a single failure to misdirection or want of direction. Of course, there was always room enough for thought on our part, but the whole character of the book is in marked contrast with the most of the photographic literature placed in the hands of the tyro of to-day with his outfit. To be sure, such a book was more necessary then than now. The discouraged tyro to-day can drop in on his older brother, entertain him with his little troubles, and receive advice and comfort; or, if they are too big for that, he can take them to the society at its next meeting. We had a society, with an excellent constitution, elaborately engrossed, and its initials, "P. P. S.," are on many unique prints, but it was not of much help to us, as we were the only members, and the constitution never could be put fully into effect for want of members to fill the offices. There were a few other amateurs, but we never discovered them, nor they us.

But to return to the Whipple process; when everything was ready, the book said, "to prepare six good plates is an hour's work," and that they would "be good for at least one month if kept absolutely free from light, moisture or deleterious atmosphere," under the latter cautioning against the neighborhood of fresh paint, varnish or ammonia. It closed that chapter with the caution that the amateur should not be "disheartened by repeated failures to get good plates," "that the difficulties were only to be overcome by sheer perseverance, with the exercise of patience and judgment," and the comforting assurance that "when success was attained

the exercise of the skill required would impart to it an attraction which the more mechanical and *infallible* methods lack," and the "infallible" was emphasized by the author. What an inspiration to patient, painstaking, thoughtful work to a boy of brains and character; what an encouragement to perseverance under difficulties! What an educational influence in this, compared with the inducements held out for the practice of photography and too much of its literature of to-day! It says, too often, "You need not know anything about anything; you need not use your brains—in fact, you needn't have any; as to skill, in fact, there is not as much needed at any stage as to turn a barrel-organ, and withal very little outlay; it is only necessary to touch a spring, or turn a crank, and the whole pictorial world is yours." After the Whipple process plates were prepared, how precious they were! They represented a great deal—not, perhaps, of money, but of what was more than money—and you may infer that the views for them were selected and studied with great care. There was not much firing at random with these plates. A little incident will illustrate their slowness. On one occasion, standing with head uncovered, the hat being used to shield the lens, we had twenty minutes to employ in speculating upon the future of photography, and fixed the ideal, unattainable limits of sensitiveness as that which would permit the simple uncovering and covering of the lens, rather leisurely at that, and yet have the picture fully impressed. We never reached the snap-shutter stage, even in imagination. But what a state of mental tension, of suppressed expectation, the development of those plates involved, as the solution—not solution "A," nor solution "B," nor a mixture of them, nor somebody's infallible ready-mixed developer—was poured over them, not in the tray of the outfit, but in the home-made tray. That developer was carefully compounded, every ingredient carefully weighed, or measured, and recognized and remembered as a friendly factor in the case. Then the injunction was to watch the plate attentively during development, to inspect its progress from minute to minute, just as with your modern plates; exactly why, how-

ever, never was very apparent, as half an hour's soaking, with all the watching, never over-developed them; but if in that time it did reveal the unmistakable outlines of a white-washed fence, or a barn, it afforded the gratification of the confirmation of our faith in the process, a realization of the fact that a spectacle-lens image could impress itself even on our plates. Although I never reached with this process that happy stage incident to a clean, well-developed negative, which our author told us was in itself a beautiful object, still the negatives, such as they were, were regarded with an affection that was not lessened by the unappreciative criticisms of our friends, who might say: "Yes, there is the fence, there is the barn, but why does it look like the deluge or midnight?" But there was more than photographic success in all this; there was that discipline that led us to venture on the apparently more mysterious and seemingly more difficult collodion process. The results of the first attempt with it were so quick, so satisfactory, so certain, by comparison, that its trial at once marked a new departure, from the dry to the wet process, which created new necessities. It required a portable laboratory, portable tent, portable silver bath, trays, bottles, etc., etc., and ingenuity was taxed to its utmost to minimize the impedimenta and to store them so as to reduce the time required for setting up and striking the tent.

This tent is only exhibited to emphasize that period of landscape photography, entirely with the past, when humidus had the field to himself. Besides the cumbersomeness of the apparatus, there were the most vexatious annoyances, caused by the photographic reagents, and especially by the unreliability of the sensitizing bath, upon which the responsibility for most of the troubles was placed, and perhaps justly at mid-summer temperatures. The literature of the nitrate of silver bath, read with avidity by amateurs of the past, would itself fill volumes in which the dry-plate amateur has comparatively little interest. The spectacular feature of the tent was not without its annoyance. A bag of yellow and black muslin, enclosing the head and body, with the lower extremities still well dis-

played below, was calculated to excite unappreciated comment, and always occasioned an unpleasant realization to the one within that the small boy might be tempted to do more. There was a dry process, however, that soon sprang up that disputed the field, and one that, although not suited to compete with the gelatine plates in rapidity, has many points to recommend it, especially for stereoscopic transparencies, as it is simple, certain and beautiful in its results and inexpensive, and would almost justify the amateur in adding the collodion bottle and silver bath to his outfit. I allude to the Tannin Process. The well-cleaned plates are coated with any good commercial bromo-iodized collodion, sensitized for five minutes in a nitrate of silver bath of forty-five grains to the ounce of water, saturated, of course, with iodide of silver, then *thoroughly* washed in water, then flowed with a filtered solution of tannin of fifteen grains to the ounce of water, and then dried. The washing is the most troublesome part of the process. It can be reduced by washing the plate in several changes of water, and then flowing it with a five per cent. solution of iodide of potassium, and then rinsing. My own practice, published a few years ago, was to prepare the plates up to this stage* in the broad daylight, and allow them to dry, as iodide of silver formed in presence of iodide of potassium is insensitive, and that formed in the film in the nitrate bath is rendered insensitive by the flowing with iodide of potassium. These plates can be sensitized at any time by immersion in or flowing with a solution of tannin. The development with pyrogallic acid, and nitrate of silver, restrained by citric acid, is simple and controllable, and the light permitted comfortable, whilst the finished negatives, or transparencies, have a rich brown tone, leaving nothing to be desired. The plates will remain sensitive for, at least, two years.

Now this retrospect as a scrap of history has little value, but the points touched on will emphasize the characteristics of early amateur photography. Those were its heroic days

* *American Jour. Sci.*, July, 1874.

There was much hard work, and there were few tangible results. If we worked for pictures, we were poorly repaid in numbers or quality, but we worked rather for light, for improvement of processes, for the detection of the subtle conditions of our oft recurring failures, and we had to find our highest reward in that exquisite pleasure of success wrung from unfriendly conditions. If our pictures were not good in every respect, we felt that we had done all to merit that highest excellence of any scientific work, the highest excellence attainable by the processes and apparatus at our command. And as we look back over those years, and note now how many have continued, or have resumed at intervals, the practice, as well as the fresh additions of thought ful, careful, enthusiastic amateurs, can we not infer that thirty years after this the camera will still be even more the *vade mecum* of many, in years of greater leisure, and that amateur photography is not simply a popular craze? The efforts of the trade to push the practice of amateur photography by any mode of presentation that may be most effective, and in any place that may be open, even by representations that are almost sure to disappoint, or that may seem to belittle the practice, may be perfectly legitimate from a business point of view, and in the end may do no harm. The boy who is inveigled into buying a Kodak, or who has a father, or a friend, that would make him so suggestive a Christmas gift, may soon find that there is something beyond the Kodak, and develop into a high-class amateur. If there are others with whom the seed may fall in shallow soil, and whose Kodaks may soon find their way to their several garrets, or to the second-hand store, this circumstance can hardly be considered an argument against the Kodak. But in this Augustan age of photography, with its perfected technique, with plates and processes and apparatus that leave scarcely any quality to be desired, for any purpose, at the command of all, is there nothing left to require and develop the highest qualities in its devotee? Certainly there is as much in it as at any time. The ground has simply changed. There are broader applications to be made, there are more subtle conditions to be

considered, there are higher excellences than those of merely technical success, there are demands for work of higher merit than that embodied in mere sharpness of definition or gradation in development. The high lights may have been allowed to take care of themselves, and the details in the shadows may have been taken care of in the development, as is so often suggested, but the result may be all the more a discredit, because of the absence of thought, of taste, or of judgment, which it discloses, and which the perfected technique, and easy methods render unpardonable as well as conspicuous. As some one has said, advances in photography have made it easy for any one to take poor pictures, but the same standard of excellence remains to-day as thirty years ago, the highest work in all respects attainable. Success does not consist in the number of shots that can be made on an excursion, but in what there is in the results to give them any value. The cheapness of plates and the ease of exposures are not promotive of the highest class of practice. A restraint should be put upon the enthusiastic sort of drag-net tendency to take everything, and trust that something will prove desirable.

But, unquestionably, the great and most natural desideratum with most who enter upon amateur practice is the rapid acquisition of that technical knowledge and skill that may render possible satisfactory results. They may be willing to put all the thought, and care, and trouble into it, but they do desire tangible returns. In a large city, and a city in which amateur photography has, perhaps, reached its highest development, few can fully realize the discouragement under which the more rural amateur works, who can only eke out his experience from the journals. A few years ago the thought occurred to me that a summer school of amateur photography, at some quiet place of resort, might meet a felt want of some. It was discussed, perhaps somewhat enthusiastically, in the hearing of a gentleman, who pigeon-holed it away, and, after a few months, I received a pressing request to organize and conduct such a school for two weeks, with conditions annexed that seemed to render success possible. I elabo-

rated a plan with considerable care, and prepared for its execution on a generous scale, and acquired considerable experience that may be of value to anyone attempting a similar enterprise. The resort was a new one, on the top of the Alleghenies, a hundred cottages and a few small hotels held the whole population. I had never seen the place, but I shipped in advance a whole car-load of apparatus, comprising a full assortment of cameras and everything that would illustrate photographic practice, and, in addition, permit half dozen popular lectures on cognate subjects. The school was well advertised, the terms were very moderate. I reached the place a few days before, only to find that not a student had been enrolled, and that no preparations had been made for it. The school of photography could not be found with a microscope. The officers of the settlement, apparently regarding the enterprise as a failure, were not to be found; not a ticket had been disposed of for the course of popular lectures, upon which they had placed their main reliance. All the same, the car-load of twenty-two boxes was taken to an unoccupied store-room, that leaked light at many crevices, but which was roomy, and the shelves and counters of which promised to be useful. Withal, there seemed to be but one chance remaining for a semblance even of success, and that lay in the possibility of presenting the practice of photography in such a way that some might consider it favorably, at least in its simpler applications. Finding the man in charge of the grounds, I advised him to have some dodgers struck off and distributed, inviting to a free lecture on photography, the evening before the appointed opening of the school. There were many ludicrous incidents connected with the whole affair up to this point, and not the least these dodgers, in their composition and mechanical execution. But perhaps 200 auditors were on hand, about the whole available population of the place. Discarding all thought of a popular scientific introductory, I began with photography, presented the leading features of its practice, dwelt upon the simpler processes in detail, exhibited a lot of blue prints, gave an opportunity to parties desiring

further information to ask questions, and invited any desiring to enter to present themselves next morning at the room. And the school was a remarkable success. Twenty-five presented themselves on time, and the number soon increased to thirty, when no further encouragement was given to enter, and unless I had been fortunate in having with me one of those unduly developed amateur professionals I would have been unable to organize and carry on the school in the absence of many of the conveniences that we are apt to consider indispensable until we are obliged to do without them. But in that excellent mountain atmosphere, often up at six in the morning, and as often not in bed before twelve at night, we ran that school for two weeks, or, rather, it ran us.

There was enthusiastic, earnest, thoughtful, continuous work, acquiescence in inevitable inconveniences and discomforts, and gratifying progress. The ages ranged from over sixty to a dozen years, all equally enthusiastic. It was not a craze. The apparatus provided for illustration and display, as far as applicable to amateur wants, was laid hold of. Fifteen complete outfits were disposed of, and others subsequently ordered, and occasionally yet a package of prints reaches me, which tells of continued interest in the practice. If you were to ask me, to what I attribute the success, under the unpromising conditions, I would answer, to the plan of the school; and there may be in it a hint for dealers, as well as for any who might wish to conduct a similar enterprise. The exercises were arranged on a progressive plan. There were four distinct courses from which to select, but as each higher course included the privilege of the lower courses, all were put upon the first course, whatever their selection. In other words, something was given the students to do, at the start, that they could reasonably be expected to do. They were tempted only to undertake what was practically certain of success, what was entirely within their range, and then they were allowed to do it, thinking and all, with the least amount of direction and supervision consistent with the proper use of their time. In other words, they were not overinstructed. Now,

there is nothing like success, and especially independent success, to whet the appetite for more and higher practice, as well as to inspire that measure, and kind of confidence so necessary in many cases. Blue printing, the first course, was therefore given a prominent place in the announcement. Most effort was expended in displaying fully its applications and possibilities. Prints of every variety were conspicuously exhibited, from large architectural plans to the humblest leaf prints. Cards, with prints from negatives, of a great variety of subjects, including series of scientific subjects, copies of engravings, landscapes, etc., were hung up, not only for inspection, but to facilitate the selection of negatives for practice by the students. No one can fully realize the attractiveness of this simplest of all photographic processes and the resources it furnishes for photographic instruction, until he has seen it properly presented to an assemblage of two dozen individuals of average intelligence, affected with the ennui of the average summer resort. It can be made introductory to all the elementary principles of photography, to the characteristics of negatives, to printing manipulations and to the acquisition of that photographic sense upon which subsequent processes may be based. The majority enrolled for this course, most without the remotest intention of going further, but after the use of negatives the desire to produce them was most natural, and the second course of wet-plate camera practice was soon entered upon with even more enthusiasm by most of them. I had anticipated a run upon this most fascinating of all photographic processes to the beginner, and was prepared with a supply of negative baths and wet-plate cameras. Silver printing was touched upon lightly. Platinum printing was regarded with more favor, as it is the process for the amateur, next, perhaps, to bromide paper, which at that time was not in the market.

After these courses, dry-plate photography almost took care of itself. All instruction in the use of the camera, focussing, selection of view, etc., had been already given, and that without the inevitable waste of time by the tyro with a dry-plate outfit running around to hunt up something

to take, and which he seldom gets, because he does not know a good negative when he sees it. A school of photography must rest upon a correct pedagogic basis, or it may be so only in name, and fail to accomplish what can be done by it. So, too, in the skilfully prepared advertisements of dry-plate outfits, accompanied by pictures of cameras pointed at running dogs or jumping horses, there is great risk of such disappointment of legitimate expectations, and consequent discouragement, that the camera it sells may soon go to the garret. Parties frequently select their subjects in advance of purchase, and even promise pictures to all their friends, and it is not a small matter, as anyone knows who has experienced it, to explain the delay in delivery long after the camera has put in an appearance. I have in my pocket a letter just received from a bright little girl, asking advice in regard to an outfit suitable to take her little brother. I have no doubt she will succeed eventually, but I see between the purchase of the camera and the realization of her wish discouraging disappointments, which a girl of twelve may not survive photographically. I have written her frankly that it is not the camera that takes the picture, but the little girl behind it, and preparing her somewhat for her first disappointments, and assuring her that if she makes up her mind not to be discouraged, she will be able to get a picture of her little brother long before he becomes a man, which she may, after all, be inclined to doubt. The point at which photography is attacked has indeed much to do with the results, and the encouragement generally is to begin as far from the beginning as possible. If dealers were to put upon the market, with some display, complete outfits for blue printing, including the preparation of the paper, with suggestions of variety of work to be done, and include series of half dozen or more carefully selected negatives for practice, I am inclined to think the sale of negative outfits would be promoted, and a broader basis for persistent amateur practice be encouraged. Now, a word as to the literature of the school. In the earlier stages it consisted of brief, carefully prepared instructions upon the exercise in hand, first given orally, perhaps with

comment, and then posted in the room for reference, all supplemented by lecturettes of twenty minutes at the opening each morning, upon such topics as the practice for the day and the experience of the previous day suggested. Their own experience rapidly put flesh on these outlines, and especially with the encouragement in the use of the ever-present note-book and always-pointed pencil, which always accompany systematic and thoughtful work. At the close of the school they were not only prepared to use a photographic hand-book, but it had become a felt want. But I leave this subject of schools of amateur photography with the simple expression of the opinion, founded on facts continually forcing themselves on my attention, that there is a place for such schools; that there may not be much money in them, but that they would at least repay financially, and would furnish much pleasure to all parties.

But there is a more purely educational phase of this subject. Not many years ago text-book cram was considered a quite satisfactory method of instruction in science and if to it were added lectures with illustrative experiments, nothing more seemed necessary or possible. In recent years work by the student is recognized as having a value of its own, not only for the acquisition of fruitful knowledge, but of still more fruitful mental discipline, which latter many still contend is the chief end of a liberal education. Whilst it is not necessary to concede that that knowledge which may be useless is best adapted to mental discipline, it can with propriety be claimed that photographic practice, as part of a liberal education, must be judged by the same rule that applies to the other branches; that even if the camera be laid aside, never to be employed again, the discipline involved in practice with it would remain just as truly as that incident to the study of algebra or of trigonometry to say nothing of the calculus, never employed in after life, or of Latin and Greek, never read or spoken, or even of that practice of music, often so faithfully carried out in early life, only to be entirely laid aside later on. Now, in the early introduction of laboratory practice by the student, it seemed, in the nature of the case,

restricted to chemical work, and always attended with liability to run into mechanical methods, by reason of the general uniformity of the processes, as well as the similarity of the phenomena. Physical phenomena more varied in character, involving broader generalizations, and more numerous laws, capable of mathematical expression, and of ready verification were excluded by reason of the demand they seemed to make for apparatus, space, and time, and an apparent necessity for high mathematical attainments as a basis of their study. Now, recognizing the principle of the best attainable results with the apparatus employed, and realizing that it is not the extent of mathematical acquisitions, but rather the ability to apply that is called into requisition, and that the educational value of a physical laboratory may lie far below the line of the calculus, arithmetic, and elementary algebra, trigonometry and analytical geometry have new value and interest imparted to them. Photography presents many features that led me to adopt it as a laboratory exercise many years ago, and to retain it at present in the physical laboratory as a valuable educational means. It is recommended by the wide range and varied character of its operations, from the simple blue print to the highest scientific applications, as well as by the progressive character that may be given to its exercises. In common with many other minor arts, its results are things, not simply facts. They can speak for themselves, and are in the main permanent, can be referred to at any time, and are comparable with subsequent results. Attention can be called by the instructor to their different qualities at different times. It also recommends itself by the severe test it affords at every stage of patience, thoughtfulness, many-sided attention to minute details, promptness in judgment and promptness of response in manipulation, as well as of skill. The work of the tyro, to the experienced instructor, bears the easily recognized earmarks of neglect, or thoughtlessness, or ignorance, or want of skill at any stage. The learner soon discovers that nature recognizes no conditions as minor or trifling in photography.

It may be objected by some that photography is largely qualitative, but it might be reasonable to inquire, whether physical laboratory practice is not made to consist too exclusively of precise measurements. Work may require skill, closeness and precision of observation, and all the qualities developed in the highest degree by quantitative work, and yet not consist in fundamental measurements of lengths, and angles, and weights, and time. It may not seem to those, who merely read the advertisements, that photographic practice requires, and encourages careful, thoughtful, precise work and skill. But nothing is more deceptive. A few years ago a section of students starting in upon photography appointed a historian. He had a voluminous account, but much of what they had learned was condensed in the motto of the title page: "It looks easy—try it." Indeed, very little practice renders it a wonder that any perfect negative should run the gauntlet of all the possibilities of failure. The demands upon the average man, too, are rather qualitative than quantitative, for quickness in estimating when the measuring stick cannot be applied. The expert samples wheat without measuring the size of the grains to a fraction of a millimetre, or weighing, though both size and weight enter into his estimate. In same way the quality of fabrics, as well as wool, cotton, is estimated. Even the physician in his diagnosis is qualitative beyond the thermometer. With the expert photographer this unconscious judgment that decides a negative to be first-class, before he begins to tell you why, seems almost a matter of feeling. Quality in these cases is the sum of many conditions, and as far as they are quantitative, rapidly estimated, not measured. In an educational photographic course there is, however, some choice of processes. Much that I have said in regard to blue prints may apply here, but for varied and peculiar excellences in this respect, perhaps no process can be compared with the wet collodion process. If it did not exist, it would be advisable to invent it for instruction. It allows the use of comfortable and abundant light, something not to be overestimated in the early practice of photography. The picture lies upon

the surface and manifests its qualities rapidly. More processes come under the observation and control of the student, and yet it is more rapid, in that completed results are reached more quickly than with the dry plates. Many experiments thus can be made in a comparatively short time. It is inexpensive, so that there can be no restraint on investigation by any thought of expense. But, perhaps, its chief value lies in the concentration in the briefest interval of time, of all the operations mental and physical that contribute to a perfect result—manipulation, observation, judgment. As you pour the developer upon the exposed plate every fraction of a second may be critical, especially with some kinds of work, as lantern slides. Not only close, quick observation, but prompt decision as to the quality of the picture, and equally prompt response of the hand to the judgment formed, involving skill, are all required. There lie between the perfect result and the barely passable one very few seconds in development. I sometimes feel as if no photographic experience can be complete without familiarity with some such process as this.

We have spoken of failures by the tyro, but among them are many the tendency to which he will never outgrow, and which should therefore cause no discouragement. Anyone is liable to get two pictures on one plate. No registering device will insure against it. Even in giving a student instruction upon this point the first puzzling indications, on one of the plates under development, rapidly grew into two dogs in two wagons in inverted positions, the unexpected interest in the picture somehow confusing the record of exposures. An experienced amateur, a D. D., had just made a snap-shutter exposure on an interesting young party playing with bean-bags in the open air. The picture was full of graceful poses and bags in mid-air, and I playfully cautioned him not to get another picture on the plate. He drew out his record book and pencilled down the memorandum, with air of one who had had some experience in that line, but, I learned afterward that, on development, there appeared upon the plate, also, the horse and buggy of a friend, hastily taken, with that obliging spirit of all

amateurs, upon a sudden call. So in the development, a plate exposed on a large stone building exhibited the startling effect of faces peering out of many of the stones, of a group that had already pre-empted the plate. Instances of the kind are numerous in every ones later as well as earlier experience, sometimes provoking but always ludicrous. A question is often asked as to the desirability of the companionship of a camera on a trip to Europe. That depends greatly on whether the camera will become the master or can be kept the servant, whether the tendency to multiply exposures, where there is so much worth taking can be restrained within anything like reasonable limits. If so, it may be a very desirable adjunct. But if it is allowed to convert a trip into a picture-taking excursion, much of the real pleasure and profit of such a trip may be sacrificed, and the pictorial results will be a poor return. On the steamer employment with the camera might prove an effective prophylactic against seasickness, or, at least, as I have found it, a great relief from the ennui of the voyage, and productive of interesting souvenirs. There are those who hesitate to take a child of three or four years, who have little doubt about their being able to manage a camera. My own experience with both is the reverse. On several occasions I have had the three and a half year old child and the camera. The latter was shipped direct to the point in Switzerland—the Zermatt region—where views, not then in the market, were desired, and there all the time and attention required were devoted to it, and it was then shipped as directly back to port on its way to America, that it might not lead into temptation along the route of travel. But the child always made the whole trip and enriched it with views peculiar to young eyes. As to the size of outfit in any case, for beginners, I invariably advise, 4 x 5, unless there are peculiar reasons for a different size, or any inclination toward stereoscopic pictures, in which case I as uniformly encourage it, and advise the 8 x 5 outfit. Many monocular views in Europe and elsewhere have a very limited value compared with that of the stereoscopic combination. Thus my own glacier views reveal almost

nothing as single pictures or lantern slides, but as stereographs possess a high value.

Great discouragement in the practice of stereoscopic photography has doubtless resulted from the fact that for so many subjects glass stereographs are almost indispensable to produce the highest effect, and these have presented peculiar difficulties in their preparation in proper position and of proper size on the glass, but I would suggest that if the recently introduced transparent flexible films are adapted to stereography, the production of transparent stereographs would be so simplified as to bring them, as far as their preparation is concerned, in competition with paper. The two binocular pictures could be printed separately, and mounted between thin cards with openings cut in them of the proper size and at proper distance from centre to centre, as I have done with mica plates. They could readily be made to fold in the middle and be sent by mail. I will only add a word upon what might be called the amateur's developer, with hydroquinone. My first trial was with Balagny's formula, with stock solutions as follows: Sulphite of soda (cryst.) 25 grammes, water 100 cc.; carbonate of soda 50 grammes, water, 200 cc.; hydroquinone 2 grammes, alcohol 20 cc. The developer was mixed from these stock solutions in proportions given. Simple in preparation, requiring few ingredients, prompt and controllable in action, suitable for plates of all makes and bromide paper as well, remaining clear and retaining its developing qualities for a month at least, in spite of frequent use, and withal inexpensive, it seemed to possess every desirable quality. A second developer, made up from the same stock solutions a few weeks later, became dark and muddy in early stages of development with the first plate. As I have received similar complaints by others, I would simply say that by the substitution of freshly prepared solution of sulphite, for the old stock solution, this objectionable feature disappeared. Doubtless the formula just given may not be the best for all purposes, but is susceptible of ready modification, and with flexible films will reduce much the trouble and uncertainties of tourist photography.

THE MANUFACTURE OF BESSEMER STEELS.

BY ROBERT W. HUNT.

[*A lecture delivered before the* FRANKLIN INSTITUTE, *January 21, 1889.*]

The SECRETARY of the INSTITUTE introduced the Lecturer, who spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

It may seem strange to some of you that I should speak of Bessemer steels. All metal made by the acid Bessemer process is generally called Bessemer steel, whether the reference is made in either a commercial or technical sense. With this I have no fault to find from a commercial standpoint, but do think technically it is too general.

I remember so vividly the troubles through which the Bessemer process passed in its earlier days; and in this connection let me remark, that it is probable that many of you do not realize the comparatively little while ago those early days existed. I do not allow myself to feel old, but I know it was after the throes of our great civil war had made many of us feel that we had already played a man's part in the great drama of life, that the first heat of steel was made by the pneumatic process in America.

Many and mighty have been the changes and developments since that time, and in none, and by none, have they been greater, or assisted more, than that same process. One of the causes which for a long time operated against the general adoption of Bessemer metal, was its being all called Bessemer *steel*, without any distinction being made as to its grade. In fact, the makers in most instances did not realize the vast range of the possibilities of the process, and themselves regarded it all as one metal. It was expected to make either a good rail, razor or a good steam boiler, with an occasional jack-knife thrown in. If the particular piece of steel happened to be suitable for the razor, the

manipulator was enthusiastic over the new metal, until he tried making boilers from plates from the same lot of ingots; he then became loud in his denunciations of its utter unreliability. In fact, the new metal was expected to be all things to all men. But the Swedes have proved that good razor steel can be made in the Bessemer converter. Remember, steel rails have conquered their vast domain, and made possible the world's great railroad systems and traffic, and many good boilers have been made from metal treated by the same general process. But different steels were used in each case. In other words, good metal can be, and is, both technically and commercially, successfully made by the pneumatic or Bessemer process, having a range of from about 0·05 per cent. to one per cent. of combined carbon.

As before stated, the process is young in years, but it has had a most wonderful development in both details of operation and amount of production.

With your permission, I will give a brief résumé of its history. Henry Bessemer, while experimenting in 1854 to obtain a suitable metal for an improved cannon, became impressed with the belief that he could, by forcing air and perhaps steam through already melted pig-iron, decarbonize and desiliconize it sufficiently to produce steel and wrought iron. He therefore continued his investigations and experiments in that direction. As he progressed he became convinced of the value of his ideas, and sought to protect them by Letters Patent. He obtained his first English patent October 17, 1854, and followed it quite rapidly with others. His American patents were secured February 12th and August 25, 1856.

Bessemer's idea was to decarbonize the bath of metal down to the point which would be suitable for the grade of steel or iron he sought to make. The physical difficulties he encountered in his experiments were simply appalling; in fact, these troubles did not disappear until some years after the process had been accepted as a commercial success. As I had occasion to say some years ago in relation to these difficulties, "It has required faith made perfect to carry one through the sea which seemed to be bounded by

no shores. As I have often expressed it, if we, knowing there was a way through all our troubles, felt so hopeless, what must have been Bessemer's pluck to enable him to persevere through his difficulties, when the desired end was known only through faith?"

In addition to the physical troubles, he encountered chemical ones. It proved impossible to always stop the decarbonization at just the proper time; and generally, if the percentage of carbon was as desired, the metal was worthless from its red-shortness, the latter being caused by the presence of burnt iron, or iron oxide, which was formed by the oxygen of the blast acting on the iron during the final stages of the process.

A. L. Holley, in a lecture delivered in 1873 at the Stevens Institute of Technology, on "Bessemer Machinery," presented the following eloquent statement: "Within the sixteen years that have elapsed since Bessemer made his first trials, his process has risen from a nearly abandoned experiment to the production of a million tons of steel per year. It has, indeed, progressed, as all successful processes do—whether fast or slowly—by the constant aid of experiment and failure; but the rapidity of its development was due, in a degree not often precedented in the iron business, to the genius of its inventor—especially to that form of genius known as perseverance.

"The difficulties of the Bessemer manufacture, although great enough mechanically to require a radically new system of enginery, were not chiefly mechanical. As soon as the engineer had surmounted his obstacle, a chemical stumbling-block rose up in the way; and his discouragement was that absolute mechanical perfection might never lead to commercial success.

"The mechanical problems, however, are of an unsually difficult character. The material treated is in a *fluid* state. As a rolling-mill man fitly expressed it, 'a puddle-ball or a rail pile will lie still on the floor, if anything breaks down; but if five tons of *fluid steel* gets the upper hand of you, there's no telling where it will *stop*.' Suitably lining vessels to hold and handle the incandescent fluid, involves all the chemical

and structural uncertainties of refractory materials. Extraordinary provisions must be made against accidents, and against serious losses, if they do occur. The reserve must be unusually strong, and the line of retreat vigilantly guarded. The excessive heat of fluid decarburized iron—not less than 4,000° F.—and its violent erosive action as it boils in the converter, demand, not only hard and fire-proof linings, but provisions for quickly renewing them; and the impossibility of maintaining the temperature while the metal is being transported and cast, requires great celerity and certainty in these operations; otherwise the metal will chill into mere scrap. In many manufactures, if an important machine fails, a little delay and immediate repairs are the only loss; but here, constant readiness and certainty of action are indispensable. Ten seconds delay in turning down a converter, when a charge is blown or a tuyere fails, may involve not only the ordinary delay and repairs, but a heavy loss on the product, and extraordinary repairs on, if I may so say, innocent organizations which have been drawn into the general disaster."

Mr. Robert Mushet, of the Forest Steel Works in England, investigated the matter and solved the great chemical trouble, by carrying on the process until practically all the carbon had been burned out of the charge, and then adding enough carbon to give the desired result, and at the same time adding manganese in a metallic form, which from its affinity for oxygen would unite with the oxygen of the burnt iron present in the bath, thus restoring such iron to a metallic state, and so taking away the red-shortness which had been so fatal to the sound working of the metal. By this invention the Bessemer process became practical.

Mr. Mushet was granted an English patent on September 22, 1856, but so little did he realize its value, that being financially depressed, he allowed it to lapse in the third year. Fortunately for him he had taken out an American patent, dated May 26, 1857, from which, owing to our laws being better calculated to protect inventors, he has received some pecuniary reward. And honor is due to Bessemer for having, after his own enrichment, settled on Mushet an

annuity of £300. The British Iron and Steel Institute awarded Mushet in 1876 their Bessemer gold medal. The English government bestowed the honor of knighthood on Bessemer and from the royalties accruing from his patents he has received several millions of dollars.

During these first years the Bessemer process was not regarded as a success, and perhaps nothing did so much to both encourage its inventor and assist him in obtaining pecuniary backing, as the success obtained from the process in Sweden. Fortunately the ores of that country were low in sulphur and phosphorus, and had some manganese. They were smelted with charcoal, and the resulting pig-iron was of exceptionally pure character, containing enough manganese to render it possible to make sound Bessemer metal without the addition of manganese after the conversion. Goran Frederick Goransson, of Sweden, accomplished this with such success and in such quantities in 1858 that Bessemer was, as before stated, not only encouraged to further efforts, but was also furnished with the argument no doubt much needed, "The Swedes are doing it!"

In relation to this, Akerman says, in his exhaustive report on the "State of the Iron Manufacture in Sweden," Stockholm, 1876: "The Bessemer method of refining has been used in Sweden from its first origin, and it is even doubtful if this process, now of so extraordinary importance, would ever have been developed, if Herr F. Goransson had not immediately after the publication of the patent, applied himself with such determination to carry out exhaustive experiments with it. For, thanks to the raw material employed, which was poor in phosphorus and in other respects of specially good quality, a completely satisfactory Bessemer product was obtained at an earlier period in Sweden than in England, and the condition of success so important for this process, that only materials poor in phosphorus are suitable for it, was ascertained."

Bessemer was not the only one whose investigations were directed towards the effect of blowing air through melted cast iron. In fact the old finery-fire process was a well-known and wide-spread example, and it was to be

expected that further development should be sought. Joseph Gilbert Martien, of Newark, N. J., but living in London, England, was allowed an English patent, September 15, 1855, for refining iron by blowing air and steam through it as it ran in troughs, while being conducted from the blast furnace in which it had been made.

William Kelley, of Eddyville, Ky., had been for some years experimenting at his works with new applications of air for refining purposes, and succeeded in commercially making in a few minutes refined metal, which had taken some hours to produce in the old finery, or run-out fires. He also obtained, experimentally, some malleable metal. He also spent all of his own money and all he could borrow.

Bessemer taking out American patents covering the principles which Kelley felt he had discovered, awakened him to the importance of protecting his rights. His application resulted in interferences with Bessemer's patents being allowed by the Patent Office, and subsequently the issuing to Kelley of patents dated January 10, June 23, and November 3 and December 22, 1857. His action prevented Bessemer receiving any remuneration from his American patents, on the process, but did not affect his mechanical patents. He subsequently sold all of them to Messrs. Winslow, Griswold and Holley, of Troy, N. Y., and Kelley received his pecuniary reward through the sale of his patents to the Kelley Pneumatic Process Company, which organization also acquired Mushet's American patent. As is well known these interests were all consolidated in 1866.

Mushet made his first heat of good Bessemer steel by the addition of spiegeleisen at the Forest Steel Works in 1857, casting it into small ingots, and the steel was used for tool purposes. This was before Bessemer or his associates had made pneumatic steel in commercial quantities.

During the years from 1854 until the new process was firmly established, the iron metallurgical world was greatly disturbed by rumors of what was being accomplished by various parties, and at many works experiments were made.

Percy relates that had it not been for an accident most

likely Bessemer would have lost the honor of his discovery. In October or November, 1855, two or three months before the issuing of Bessemer's first patent, George Parry, of the Ebbw Vale Iron Works, fitted up the hearth of a reverberatory furnace with a series of pipes in which many holes had been drilled. Plugs were inserted in these holes, and the pipes carefully covered with refractory material, which was dried, the resulting cracks filled up and then the plugs withdrawn. This system of pipes was connected with the blast from a blowing engine, the furnace brought up to a high heat and a charge of melted iron run into it, the blast having been first turned on. By some accident a leak occurred in the furnace, before the process had continued very long, and the metal ran out on the ground. Mr. Parry wanted to make another trial, but the proprietors of the works objected, and so Bessemer's glory was saved to him.

While Mushet was waiting for the completion of his small converter at the Forest Works, he obtained, early in 1857, some Bessemerized metal, or metal which had been desiliconized and decarbonized by the Bessemer process, from the Ebbw Vale Works, and remelted it in ordinary steel crucibles, putting forty-four pounds in each, to which, when melted, he added two pounds of melted spiegeleisen. He cast ingots, weighing some 500 to 600 pounds, and from one of them had a double-headed rail rolled at the Ebbw Vale Iron Works. This was put in the track of the Midland Railroad at Derby Station, at a point where iron rails had lasted but a few months. The steel rail remained in this service until June, 1873, after successfully withstanding the passage of over one and a quarter million trains. This was undoubtedly the first Bessemer steel rail, if it can be rightly so-called, ever put into service, and I know of no record of a previous one having been rolled.

Notwithstanding the reported success of the process in Sweden, and the attention which it had attracted in England, it met with much opposition, and many authorities of note did not hesitate to predict its failure. I can readily understand how a prudent engineer, to say nothing

of a sensitive capitalist, must have felt grave doubts about its success after witnessing one of the "messes," which, for so long a time, were such prominent and persistent features of the process. The percentage of waste and scrap often exceeded that of the metal which was gotten into ingots, while it was almost an even thing whether or no the metal of those ingots was of the grade desired. So it was not until 1863 that active steps were taken towards the introduction of the process into America. In that year, the Kelley Pneumatic Process Company was organized, and they soon commenced the erection of experimental works in the casting-house of a blast furnace at Wyandotte, Mich., and in these works, in the fall of 1864, the first American pneumatic, or Bessemer steel, was made, the works being under the charge of Mr. William F. Durfee.

The first steel rails made in this country were rolled at the old or north side mills of the North Chicago Rolling Mill Company, on May 24 and 25, 1865. This was simply an experimental rolling of six rails from steel made at the Wyandotte Works. The first commercial rolling of steel rails did not occur until August, 1867, when the Cambria Iron Company, at their mills, in Johnstown, Pa., executed an order for the Pennsylvania Railroad Company, from steel made by the Pennsylvania Steel Company, at their works, near Harrisburg, Pa.

From that time on the advance has been rapid, and the development so great, that the history of the early days seems like a dream.

In our country's centennial year, I relieved my patriotism by reading in this very hall a paper before the American Institute of Mining Engineers on the "History of the Bessemer Manufacture in America." In it I gave with great pride the largest yields which had been made by the various American Bessemer works, and compared them with what eight years before had been considered satisfactory results, when 10,000 tons of ingots was named as the maximum annual output of two five-ton converters. I find on referring to that "History" that, while all had records of which to be proud, the North Chicago Rolling Mill Com-

pany headed the column; their banner results being 330 gross tons of ingots for twenty-four hours; 1,583 gross tons for the week, and 6,457 gross tons for the calendar month.

To-night, some twelve years later, I can give figures quite as startling in comparison with these, as they were in relation to the early records. If I am correctly informed the largest output ever reached by any Bessemer plant, to say nothing of being produced in two converters, was that of the Union Steel Company, of Chicago, in May, 1888, when, in their two ten-ton converters, they made the following record: Best twenty-four hours, 1,448 1000/2240 gross tons; best week, 6,271 gross tons; calendar month, 28,145 1640/2240 gross tons of ingots. In the same month they rolled on one rail train 22,808 0799/2240 gross tons of rails. While this gave them the "broom," their tenure is a precarious one, as they beat the best work of several other American plants by a somewhat limited margin.

I find one singular fact to exist in this connection, and that is, in my "History," previously mentioned, I say, in speaking of the North Chicago Works: "The first blow was made on April 10, 1872, under the direction of Mr. Robert Forsyth. * * * This gentleman has ever since remained in charge of the converting works, and has been most eminently successful in his management. His works are to-day making the largest output of any in the world." And I must now say to you that the Union Steel Works, of Chicago, were designed and built, and have ever since been operated under the management of the same gentleman. The only way I can account for this instance of "history repeating itself," is by again quoting from my history, where I said, he "had received his Bessemer education at the Troy Works."

The product of Bessemer steel in Great Britain and the United States for 1887 is given by James M. Swank, General Manager American Steel and Iron Association, to have been 5,025,436 gross tons; of which the United States made 2,936,033 tons, or more than one-half.

In 1888 it was much less, owing to the want of demand. The totals of ingots have not yet been ascertained for either

country, but the United States made 1,364,337 gross tons of rails.

In 1887, the question put to the managers by the commercial ends of the Bessemer steel-producing organizations was: "Can you make all we can sell?" In 1888, unfortunately for the pecuniary returns of the business, the same gentlemen informed the same managers that: "We can't sell what you can so easily make." I expect, if such had not been the case, Messrs. Fritz, Jones, Bent, Smith, Potter, *et al.*, would have compelled Mr. Forsyth to have made another record to have retained the lead. Hence, we may expect new best figures the next time we have the pleasure of discussing the question. There does not seem to be any limit.*

Chemical knowledge and investigation early played a prominent part in Bessemer history. Unfortunately the processes of the analysts had not then reached the same refinement of determination which they possessed later. Hence, what were then called "traces" are now accurately determined and found to be of sufficient quantities to account for some of the early unsatisfactory and inexplicable results.

After the application of Mushet's invention, and the

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* As anticipated, the output of the Union Steel Company has been surpassed by both the North Chicago Rolling Mill Company, under the management of E. C. Potter, Vice-President, and the Edgar Thomson Steel Works, directed by General Manager Capt. Wm. R. Jones.

In January, 1889, North Chicago produced:

Gross tons of ingots,	27,427
Gross tons of rails,	22,976

Their best work for twenty-four hours was:

Gross tons of ingots,	1,393
Gross tons of rails,	1,248

which is still the best on record.

In March, 1889, Edgar Thomson made:

Gross tons of ingots,	31,120	900/2240
Gross tons of blooms,	27,790	1420/2240
Gross tons of rails,	25,342	2008/2240

This gave that works the "broom." Will they keep it?

April 17, 1889. R. W. H.

development of Bessemer's mechanical devices, and the practical determination of the proportions of certain chemical elements which rendered some irons unfit for the process, the minds of metallurgical investigators of both hemispheres were directed toward the solution of the problem as to how those impurities could be eliminated. As you know, phosphorus was the element exerting the most powerful and persistent influence, and unfortunately the largest proportion of the world's available iron ore supply contains too much of that substance to permit the use of metal made from it in the ordinary Bessemer process. In it, phosphorus is increased to the extent of the loss incidental to the operation.

Much time and money have been spent on this problem. Chemistry taught that it was impossible to eliminate phosphorus in the presence of an acid slag, and that it was equally out of the question to have a basic one, so long as you protected your converter with an acid lining. Therefore, all required was to substitute a basic one. That was easily done, but the trouble was to find such a lining which would resist the fluxing action of the charge while being decarbonized and desiliconized. In this search was spent much money and more time.

The well-known chemist and metallurgist, George J. Snelus, of England, was the first to nearly reach practical success, and he patented his invention in 1872. But it was some five years afterward that Sidney Gilchrist-Thomas, assisted by his cousin Percey C. Gilchrist, was rewarded for their exertions by making an absolute success of dephosphorizing iron in a Bessemer converter, by lining the same with lime, and adding lime to the melted iron. This they patented November 22, 1877. These gentlemen soon consolidated their interests with Mr. Snelus. The process is known as the "Thomas-Gilchrist or Basic Process." The solution of the difficulties in making the linings and bottoms of the converters resist the action of the charge, was in the character of limestone used and the manner of preparing it. But it was also discovered that the pig-iron to be treated must also be within certain chemical proportions.

In the regular Bessemer, or acid process, the burning out of the silicon of the iron treated is largely depended upon to furnish the necessary heat to keep the metal sufficiently liquid, while being subsequently cast into ingots, to avoid loss from "sculls" and other scrap, consequent upon its chilling. But the chemical action of the silicon is very severe on the lime linings, and as it was found that the elimination of phosphorus caused heat, it therefore became manifest that the metal best adapted to the basic process was one high in phosphorus and low in silicon.

The keeping up of the basic linings, lessening of product, and other details of the basic, requires that the pig metal used must cost from two to three dollars per ton less than that used in the acid, to place the two processes on an equal commercial basis, leaving out of consideration any question as to the relative value of their resultant metals.

The Thomas-Gilchrist Process is extensively used in Europe; the greatest development being in Germany. As yet it has not made much headway in the United States. The Pennsylvania Steel Company some years ago made some experiments with it in their old or original Bessemer plant; and since then Messrs. Morris, Wheeler & Co., have built a regular basic plant at Pottstown, Pa. Of course, these companies met with the usual troubles incident to the introduction of a new process, but I suppose the greatest difficulty has been their inability to obtain suitable irons at a sufficiently low price.

After the application of Messrs. Thomas & Gilchrist for American patents, Jacob Reese, of Pittsburgh, urged his claims for priority of invention, and it resulted in Letters Patent being granted him. Considerable litigation has ensued, and no doubt the uncertainty attending the legal status of the process has had a restraining influence on the establishment of basic works in the Southern States, where it would seem suitable iron could be cheaply produced.

There have been numerous other patents allowed, but they have failed to attract much attention.

As is well known, rails have absorbed the largest proportions of metal made by the Bessemer Process. But from the

very beginning other grades of steel have been produced with greater or less success. The Swedes have continued since Goransson's early experiments, to make good metal of both high and low carbon in their various forms of Bessemer converters. No doubt many of you recall the wonderful and beautiful Swedish exhibit in our Centennial. We there had steels made by the Bessemer Process worked up into many forms, from heavy forgings to the most incisive cutting instruments of domestic life, surgery and war.

The stagnation in the rail business at various periods, and the constantly increasing production, have been, and are a constant pressure toward putting the output of the converters into some other form. I devoted much attention in this direction while in charge of the Troy Works, and met with some degree of success.

In regard to whether certain rails are of the best quality or otherwise, generally a considerable period of time must elapse before the question can be definitely answered, but with so-called special steels, the determination is reached much quicker; hence, if your metal does not make good drills, cutlery, springs, gun barrels, drop forgings, etc., the maker hears from it very soon in a manner not at all pleasant, and he has much less opportunity to talk back, than when treating with his railroad friends.

Observant steel makers have long realized the influence of temperature on the quality of steel while it is being made, quite as much as during its subsequent manipulations. This is true whether the process is conducted in the crucible, open-hearth furnace, or Bessemer converter. But I think the Bessemer people have not generally been as alive to the importance of this fact as their brethren of the other processes.

Dr. Thomas M. Drown, in his paper on, "The Latest Development of the Bessemer Process, or the Blowing of Small Charges," read before the Society of Arts, Massachusetts Institute of Technology, May 27, 1886, treats very intelligently and interestingly on this subject. But he devotes his attention to soft steels or ingot irons, giving results obtained by the Avesta, Prevali, and Clapp-Griffith

converters. I do not venture to dignify any of them as processes. Perhaps my friend, Harry W. Oliver, will appreciate the cause of my timidity.

Let me, at the same time, say, that where it has been intelligently conducted the Clapp-Griffith converter has continued to yield satisfactory results.

However, the importance of temperature is not confined to the production of soft metal, it extends up the whole range of carbons.

I believe now, as I have always, that the more nearly you can have metal composed of only iron and carbon, the closer you will be to the ideal. Unfortunately in this, as in many other human matters, we cannot attain that sublime altitude, and so must be content to do the best we can with that which is vouchsafed us. If we can make one impurity offset the bad effects of another, we will accomplish the results which will be more orthodox in the metallurgical, than the religious world.

As we are forced to put up with the presence of silicon, sulphur, phosphorus, and manganese, we must endeavor to compel as many of them as possible to be our allies. Leaving phosphorus out of consideration, we will first consider the effects of silicon. This element is recognized as valuable in rendering steel castings sound, or free from "blow-holes," but has been generally regarded with disfavor by other steel makers. I do not fully agree with them in this condemnation, when other than the very soft or high phosphorus metals are considered. Some years ago I made quite a full investigation of the composition of various steels of approved brands, and which had given satisfaction to many users for various purposes. I was particularly interested in my silicon results, and I herewith present some of them.

A sample of what was known as New England hoe steel, used with satisfaction by Messrs. Lane, Gale & Co., in making their celebrated "Planters Hoes," gave:

Carbon,	0·76
Silicon,	0·185
Phosphorus,	0·059
Manganese,	0·441

The same firm gave me a sample of another steel which they designated as "scarf steel. It contained:

Carbon,	0 52
Silicon,	0·150
Phosphorus,	0·068
Manganese,	0·406

The Providence Tool Company of Providence, Rhode Island, at that time filling large contracts for rifles for the Turkish government, used for the "circles and plungers" of the gun:

Carbon,	0·66
Silicon,	0·171
Phosphorus,	0·057
Manganese,	0·416

The Hartford Machine Screw Company used a steel containing:

Carbon,	0·46
Silicon,	0·223
Manganese,	0·316

Messrs. Huntly & Babcock of Utica, N. Y., liked a brand of steel for making hoes, with the following composition:

Carbon,	0·61
Silicon,	0·158
Phosphorus,	0·086
Manganese,	0·445

For "Pitch" and other large forks their steel gave:

Carbon,	0·63
Silicon,	0·241
Phosphorus,	0·073
Manganese,	0.610

The Remingtons gave me samples of steel which they liked for making "Planters'" hoes, which analyzed:

Carbon,	0·52
Silicon,	0·150
Phosphorus,	0·043
Manganese,	0·376

For "goose-neck" hoes:

Carbon,	0·53
Silicon,	0·249
Phosphorus,	0·040
Manganese,	0·413

In spring steels, I found "Jenk's" English, a favorite brand, had:

Carbon,	0·64
Silicon,	0·145
Phosphorus,	0·088
Sulphur,	0·005
Manganese,	none

A second sample obtained from another user gave:

Carbon,	0·52
Silicon,	0·150
Phosphorus,	0·060
Manganese,	0·034

One sample of "Greaves" Swedish spring steel analyzed:

Carbon,	0·53
Silicon,	0·110
Phosphorus,	0·030
Sulphur,	0·015
Manganese,	none

Another sample:

Carbon,	0·76
Silicon,	0·84
Phosphorus,	0·018
Manganese,	0·085

Naylor's spring steel, from the Bridgeport, Conn., Works, contained:

Carbon,	0·65
Silicon,	0·185
Phosphorus,	0·102
Manganese,	none

Leaving these, which may be considered of the coarse grades of steel, we will consider steel used by the Johnsville, N. Y., Axe Works for hatchets. It analyzed:

Carbon,	0·70
Silicon,	0·270
Phosphorus,	0·041
Manganese,	0·195

A steel used by Ames & Co. for making swords had:

Carbon,	0·64
Silicon,	0 258
Phosphorus,	0·017
Manganese,	0·453

A. S. Millard, a celebrated maker of scythes, gave me as representing a German brand of steel, which he had used with the utmost satisfaction for thirty years, a sample which contained:

Carbon,	0 63
Silicon,	0·127
Phosphorus,	0·056
Sulphur,	0·c05
Manganese,	0·212

Of cutlery steels, Messrs. Sanders, Ferry & Clark, New Britain, Conn., gave me "knife" steel having:

Carbon,	0 51
Silicon,	0·18
Phosphorus,	0·029
Manganese,	0·265

"Fork" steel:

Carbon,	0·49
Silicon,	0·335
Phosphorus,	0·03
Manganese,	0·444

Also a sample of Park Bros. & Co.'s, cutlery steel, containing:

Carbon,	0·61
Silicon,	0·210
Phosphorus,	0·046
Manganese,	0·402

Messrs. Park Brothers' Black Diamond Tool Steel, which then sold at fourteen and one-half cents a pound had:

FIRST SAMPLE.

Carbon,	0·88
Silicon,	0·220
Phosphorus,	0·023
Manganese,	0·14

SECOND SAMPLE.

Carbon,	0·85
Silicon,	0·204
Phosphorus,	0·022
Manganese,	trace

Frith's English tool steel contained:

Carbon,	0·85
Silicon,	0·19
Phosphorus,	0·022
Manganese,	0·174

Another sample of Park Brothers' Black Diamond Tool Steel analyzed:

Carbon,	0·86
Silicon,	0·216
Phosphorus,	0·030
Manganese,	0·091

I have before related that while I was making these investigations, and at the same time endeavoring to produce in the Bessemer converter steels to take the place of those, or as it was apt to be commercially put, "fill the bill at a less cost," I made a visit to the works of a firm, the members of which were and are highly esteemed by me, and whose products of the higher grades of steel have the very highest reputation. These gentlemen have always been progressive, and therefore their utterances are not likely to be controlled by prejudice; hence carry with them great weight. On the occasion of my visit I was full of what I was accomplishing in my converter. They treated me kindly, but said I must not expect too much. That in making the harder steels I would find silicon my constant enemy. As they happened, while we were talking, to be testing a piece of their own steel which was yielding splendid results, one of them said

to me: "My dear fellow, when you can make such steel as that in your Bessemer converter we will begin to believe in it." I was thrown into a depressing state of humility and could with difficulty muster courage to beg a piece for analysis. It was most cheerfully given. The result was:

Carbon,	0·86
Silicon,	0·306
Phosphorus,	0·016
Manganese,	0·195

About this time several American makers of rifles and pistols were filling European contracts for both the Russian and Turkish governments. Most of them were using foreign iron and steel; the iron being of special brand known as "Marshall." Supplying the requirements of these firms presented a tempting field, and we devoted ourselves to it. It did not prove such an easy matter as we fondly hoped, and it was only after numerous trials and some failures that we attained success. But we soon learned that to give a satisfactory gun-barrel steel, the manganese must be kept somewhat low. Increasing it might make the steel sound and roll well, but it also caused it to throw a long chip before the drilling tool. This was very objectionable, as such chips would throw the necessarily long and slender drills out of line, and thus cause them to run to one side of the rifle barrel. A very satisfactory metal had the following composition:

Carbon,	0·29
Silicon,	0·212
Phosphorus,	0·048
Sulphur,	0·065
Manganese,	0·370

It is well known that manganese has a strong influence on the tempering characteristics of steel. Therefore, it must not be in excess in any metal which will be tempered. It causes water-cracks and other undesirable qualities.

In considering rail steel, I will not trespass on your time and patience by going over the history of the steel-rail business, although familiarity with it is necessary to fully understand some of the points bearing on the manufacture of rail steel.

Suffice it to say that we have good reason to feel that all rails are not as good as they ought to be. Perhaps, regarded in the same light as wearing apparel, they are good enough for the money paid for them, but as rails, some rails ought to be better.

I have dwelt somewhat on the chemical composition of steels, and but briefly referred to the effect of the physical features of their manufacture. Let us return to that branch of our subject. When general attention was first called to the somewhat unsatisfactory results which were being obtained from the wear of the rails made during the later years, great stress was put upon their chemical composition, and chemical analysis was expected to tell the cause of the trouble. This branch of investigation was followed, and several interesting and ingenious theories built up. But unsatisfactory rails continued to be made, and the analyses of those which had yielded good service demonstrated that many of them were at variance with the theories, and also that their chemical composition was like many that had failed—in fact, did not have any uniformity, but ran through almost the entire gamut—it would seem that some other than chemical causes must be sought to account for their good wear and the bad behavior of others.

Rails made by John Brown & Co., of England, and put down on American railroads some years ago, have been generally held up as ideal rails, and the American makers for a long time supposed that when these rails did wear out, so that they could be analyzed, the secret of their good service would be told. As illustrative of how little regularity or purity of chemical composition influenced their wear, I call your attention to the analyses of thirteen John Brown rails, all of which had filled years of faithful service, and been selected as bright examples of what good rails should be.

	Carbon.	*Silicon.*	*Phosphorus.*	*Sulphur.*	*Manganese.*	*Copper.*
1	0·35	0·08	0·128	0·068	0·742	0·048
2	0·39	0·071	0·156	0·155	0·662	0·32
3	0·36	0·103	0·125	0·060	0·815	trace
4	0·70	0·306	0·111	0·058	0·681	0·016
5	0·36	0·069	0·153	0·131	0·621	0·043

	Carbon.	*Silicon.*	*Phosphorus.*	*Sulphur.*	*Manganese.*	*Copper.*
6	0·44	0·208	0·098	0·059	1·046	none
7	0·45	0·102	0·128	0·105	0·616	0·056
8	0·36	0·087	0·148	0·181	0·625	none
9	0·24	0·068	0·131	0·104	0·645	0·008
10	0·37	0·051	0·098	0·050	0·639	trace
11	0·32	0·089	0·145	0·077	0·745	trace
12	0·35	0·069	0·077	0·099	0·945	none
13	0·28	0·032	0·084	0·053	0·312	none

You will observe that the carbons ranged from 0·24 to 0·70; silicon, from 0·032 to 0·306; phosphorus, from 0·077 to 0·156; sulphur, from 0·050 to 0·155; and manganese, from 0·312 to 1·046. These thirteen rails taken as a whole were chemically a "poor lot," but physically most excellent. As these results are fortified by many others, we are compelled to think that physical peculiarities of their manufacture must account for their superiority.

In a paper on "Steel Rails and Specifications for their Manufacture," which I had the honor of reading before the American Institute of Mining Engineers, I gave instances of rails having practically the same chemical composition and of the same sections in the tracks of the same road and subjected to the same conditions, which had given opposite results. To repeat one example; a rail wore *soft* which analyzed:

Carbon,	0·39
Sulphur,	0·059
Phosphorus,	0·085
Manganese,	0·722

While another wore *hard* and contained:

Carbon,	0·40
Sulphur,	0·064
Phosphorus,	0·080
Manganese,	0·779

I also took the position that rail sections were largely responsible for the good or bad wear of the rails rolled to them. I will not now repeat my argument on this point; but one thing is certain, no matter how good the section may be, we cannot expect satisfactory results unless the

steel going into it is properly treated in all the stages of the rail's manufacture.

First, the temperature of the conversion must be controlled. Second, the recarburizer must be thoroughly mixed throughout the mass of blown metal. Third, time and opportunity must be allowed for the escape of the confined gases. Fourth, care must be exercised in pouring or casting the ingots; not only in keeping the steel from spattering against the sides of the ingot moulds, but also that the final manner of pouring each ingot shall act as a sink-head, and the gases allowed to escape so that an excessive length of spongy tops to the ingots shall not be made. Fifth, the ingots must not be taken from a perpendicular position until the interior steel has had time to solidify. Sixth, the steel must not be overheated in the heating furnace, of whatever form it may be, either while in the shape of ingots or blooms. Seventh, all defects should be carefully cut off and out before the steel is put into finished shape. Eighth, the temperature of the metal while receiving the final passes, or reductions in the rolls, should be low.

Observe these rules, and the steel of 1889 will be just as good as that of 1868. The early makers did not know so much more than the present ones. They knew much less. In fact they blindly followed as closely as possible the traditions of older processes. There had not yet been any made for this one. We do not want to advance backwards, but we will not gain by casting away that which has proven to be good, unless we can replace it by something better.

To return to the manner of casting ingots, and the importance of keeping them in an upright position until the interior metal has solidified. Rails have failed at the ends by crushing down and splitting, sometimes the one or the other, other times both. The usual reason given has been that enough steel was not sawed off the end of the rail after it was rolled. When this statement was made, during the somewhat celebrated Dudley steel-rail discussion before the Mining Engineers, Dr. Dudley replied, that he had found rails on the Pennsylvania Railroad which would have required being cut in two in the middle and both ends

thrown away; and he undoubtedly was right, for many rails have crushed and split at other points than the ends. But we did not seem to be able to account for it so frequently happening.

Last summer Mr. Robert Forsyth, General Manager Union Steel Company, made some investigations as to the effect of placing ingots on their sides before the interior steel had solidified. From a number of heats he had one ingot drawn from the casting pit as quickly as possible and laid on its side; while the next ingot to it was allowed to remain in an upright position. These ingots when cold were broken under a drop, and photographs taken of the pieces. Mr. Forsyth has kindly placed these at my disposal, and we will have some of them thrown upon the screen, and I hope the pictures will be plain enough for you to appreciate the difference in the character of the several ingots. Please remember that they are in pairs from the several heats of steel, so that the same history applies to both up to the time of being drawn from the casting pit. It is true that Mr. Forsyth was hoping to sustain the theory that ingots should remain on end, and so we most likely have presented extreme cases, but even if so, it is shown what can occur.

Figs. 1 and *3*, of Plate I, are of ingots too quickly thrown upon their sides, while *Figs. 2* and *4*, of Plate I, are of their companion ingots which had been allowed to stand on end until cold. In the former are plainly shown the longitudinal cavities, formed by the settling of the interior liquid steel; while in the latter these cavities become cup-shaped at the top ends of the ingots and can be cut off. They are coated with iron oxide and will never entirely weld up during the subsequent working of the steel. Had more time been taken in casting these ingots, both the longitudinal and top cavities would have been less; but, as before stated, these broken ingots illustrate dangers to be carefully avoided.

Following these (see Plate II) we have sections of rails which were undoubtedly rolled from ingots with such longitudinal defects. *Fig. 5* is from a photograph of a broken rail which caused a wreck. In this case the thinnest wall

of steel surrounding the cavity happened to form the top of the rail, and it split open. *Figs. 6* and *7* are from etchings of rails, which plainly show the same character of defects. In *Figs. 8* and *9* we have etchings from sound, close-grained rails; *Fig. 9* showing better than *Fig. 8*, and it has proven its good character by some years of faithful service.

I could repeat these by the hundreds, but it would be needless repetition and waste of time.

I am indebted to F. A. Delano, of the C. B. & Q. R. R. Co., for many etchings of rail sections—these among others—and feel confident his careful investigations will result in valuable additions to our knowledge.

The development of the Bessemer manufacture has been most wonderful in the increase of production and lessening of cost. I believe the present, while a lull exists in the demand, is a good time to consider means looking toward the maintenance of the quality of the product on a higher plane. Having so completely mastered the mechanical difficulties, such results can be reached without adding but a trifle, if at all, to the cost of the finished steel. Care is always true economy. If cost of production is seemingly increased by more time being taken at certain points of manufacture, I believe that it will be more than made up by the lessening of repairs and wear and tear, and, in fact, the time itself will be recovered at other stages of the operation.

There is one remarkable thing connected with the American history of this process. From the very first there has existed the greatest professional rivalry between the various works; at the same time the warm personal friendships for each other of those having the works in charge have never been broken. Always willing to exchange ideas and experiences, and then each using the benefit of them to push ahead, and this understood and acquiesced in by all.

While the loved and lamented Holley lived, he spread his all-loving nature over all of us. Since his death it would seem as though his spirit was still here to protect this process for which he did so much, and to shield the happiness of those who loved him so well.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS.

THE MIMEOGRAPH DUPLICATING SYSTEM AND APPARATUS.

[No. 1410.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 1, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE MIMEOGRAPH DUPLICATING SYSTEM AND APPARATUS, OF THOMAS A. EDISON, OF MENLO PARK, N. J.,

Report that: The application is made under date of August 15, 1888, by F. Z. Maguire, General Agent for Pennsylvania.

The apparatus is called the Mimeograph, and is intended to be used for duplicating autographic and type-written work, drawings, music, etc. In its operation it is claimed to be an improvement on pre-existing methods of duplicating, including some new features. The principle employed is not new, consisting in puncturing a sheet of paper or similar material with small holes along the lines to be reproduced, thereby making a stencil. This is placed on the surface to be printed, and a coloring material rubbed or pressed on it, so as to be forced through the holes on to the surface below, which is thereby printed.

The apparatus for autographic duplicating, and the operation may be described as follows: There is a hardened steel plate, the surface of which is covered with fine points, to the number of about 200 to the square inch, formed by scoring it with grooves. This plate is made one and one-half inches or three inches wide, and long enough to extend across the width of the stencil sheet, which is to be prepared, and it is set in one end of a convenient wooden frame. A slab of slate, or other suitable material, is set in the

remaining portions of the frame, the top surface of all being flush, and making a level bed. The stencil sheet, which is a thin paper covered with paraffine, is laid on this bed, the part of it to be written on being kept over the steel plate. The writing or drawing, which it is desired to duplicate, is then done with a smooth pointed steel stylus, which is used with about the same pressure and ease as a lead pencil. As the stylus passes over the stencil paper the latter is pressed down on the steel points, so that they are driven through it, making numerous small holes along the lines which the stylus traverses. The stencil thus prepared is placed between the two frames, one of which slides within the other, and is clamped down, so that the stencil is thus stretched smooth and securely held. These frames carrying the stencil are then hinged at one end to the bed, the sheet to be printed is placed on this bed and the stencil brought down upon it. An ink roller, covered with semi-fluid ink, is then passed over the stencil, pressing the ink through the holes which have been pierced in it, down on to the paper below, thus making the desired impression upon it. Printing may de done in this way very rapidly, at the rate of several hundred an hour, and one stencil may be used for as many as 3,000 copies before it is worn out by the enlarging of the holes.

To prepare a type-written stencil: The edges of a sheet of paraffine paper are folded over a piece of coarse silk cloth, back of which is laid a stiffening sheet. They are then passed through a typewriter in the ordinary way, except that no ribbon is used. The type strikes the paraffine paper, driving it against the silk cloth, which is termed "perforating silk." Wherever the type strikes, the paraffine is taken up by the cloth on the other side, and owing to its coarse texture, small holes are pierced through the paper in the lines of each letter. Copies as good as actual typewritten work are taken from the stencil thus made by placing it in the printing frame and using the inking roller as before described. From 1,000 to 1,500 copies may be made from one stencil. The type is not at all injured, as in some processes, merely needing occasional cleaning.

The sub-committee has examined the apparatus, its operation and the work produced, and is very favorably impressed with the results obtained. It has also made some investigations into other methods of preparing stencils for printing, and in no instance in the comparison has its judgment been unfavorable to the mimeograph. The method employed of puncturing the stencil sheet from below upward, by pressing upon a slab covered with numerous small points, is believed to be original and worthy of special commendation. Perforations so made, being largest toward the surface to be printed, make a fuller and more continuous line than those made from above. The apparatus is deemed very useful for the purpose for which it is designed, and the Sub-Committee recommend the award of the John Scott Medal to the inventor.

[Signed] W. R. WHARTON,
JOHN R. MCFETRIDGE,
WM. MCDEVITT.

Adopted January 2, 1889.

[Signed] S. LLOYD WIEGAND, *Chairman.*

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, April 16 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 16, 1889.

Mr. H. PEMBERTON, Jr., President, in the Chair.

Members present: Dr. H. W. Jayne, Dr. Wm. H. Wahl, Dr. E. F. Smith, Dr. S. C. Hooker, Dr. H. F. Keller, Dr. D. K. Tuttle, Prof. Henry Trimble, Prof. R. L. Chase, Prof. N. Wiley Thomas, Messrs. T. C. Palmer, Reuben Haines, J. H. Eastwick, W. L. Rowland, W. W. McFarlane, W. H. Bower, F. Lynwood Garrison, Lee K. Frankel, A. W. Allen, Dr. Wm. C. Day and three visitors.

The Treasurer made a brief report, stating the present condition of the finances of the Section.

The following gentlemen were nominated for membership in the Section: Dr. L. I. Morris, 2505 Oxford Street, Philadelphia; Dr. Persifor Frazer, Drexel Building, Philadelphia; Mr. Fred. E. Ives, corner of Ninth and Filbert Streets, Philadelphia; Mr. Theodore D. Rand, No. 17 South Third Street, Philadelphia.

The President called attention to the contradictory character of two of the by-laws and recommended correction; he also recommended that one member instead of two, as at present required, be sufficient to nominate a candidate for membership.

The resignation of Dr. Isaac Norris, of 1424 Walnut Street, Philadelphia, was accepted.

The President called the attention of the Section to the fact that copies of the papers read at the last meeting had been sent as advance sheets by the Secretary to various chemical journals in the United States and abroad.

Dr. Wahl recommended that the Section continue subscription to *Fittica's Jahresbericht* recently purchased by the INSTITUTE; on motion it was unanimously voted to adopt this suggestion.

Upon the recommendation of Dr. Jayne it was decided to consider Mr. Pedro G. Salom as a member of the Section from date.

Dr. S. C. Hooker then read a very interesting paper, in which he gave the results thus far obtained in a series of sanitary analyses of the hydrant water supply of Philadelphia. These analyses include determinations of chlorine, of free and albumenoid ammonia by the Wanklyn process and nitrogen in nitrates, according to the carbazol method devised by him. These analyses are to be systematically conducted at regular intervals in the future, and the results are to be embodied in future papers to be published in the JOURNAL OF THE INSTITUTE.

This paper called forth a very active and interesting discussion, which was participated in by many of the members present.

Mr. Haines suggested that in the investigation of the Philadelphia water supply, proposed by Dr. Hooker, special attention be directed to those districts which are affected with typhoid fever. In Germantown, in the Twenty-second Ward, typhoid fever has been unusually prevalent for more than a year past, but during the last three months it has increased to such an extent as to produce a general feeling of alarm and to call for a special investigation by the Board of Health. Unfortunately this investigation does not appear to have been as thorough and extended as the case demanded. It is believed that there have been in Germantown a larger number of cases of typhoid than in any other section of the city, except, perhaps, the district of Kensington, where this disease has prevailed for many years. By very many residents the disease is attributed to the Schuylkill water, which is supplied to Germantown from Flat Rock Dam, the uppermost of the pumping stations, by the Philadelphia Water Department. Prof. A. R. Leeds, of Stevens Institute, Hoboken, N. J., has stated in positive terms that the Schuylkill water has been the cause of typhoid fever in some cases. Very many residents of Germantown will not drink the river water unless it is boiled and filtered. There is, in consequence, a disposition to resort to well water instead of the river supply, a proceeding which is far more dangerous, for a large proportion of these wells, which are quite numerous, are undoubtedly contaminated with sewage.

A prominent physician, long a resident of Germantown, and who has had many of these typhoid cases, believes, on the other hand, that the disease cannot be attributed to the Schuylkill water.

Mr. Haines alluded to other causes to which the typhoid might be attributed, among which was the prevailing unsatisfactory condition of house drainage, especially in the older dwellings in Germantown, very many of which have not been arranged in accordance with the recent regulations of the Board of Health, not being properly trapped, and having no ventilating pipe to the soil pipe. Some of the houses built during the past few years are also believed to be in an unsafe sanitary condition, in consequence of improper or imperfect plumbing fixtures. The probability of a contaminated and adulterated milk supply being the cause of typhoid fever, was suggested by Dr. Tuttle.

Mr. Haines also alluded to the fact that Dr. Thos. M. Drown, of the Massachusetts Institute of Technology, has recently applied the Kjeldahl process for organic nitrogen to the determination of organic matter in water. The

result appears to warrant the belief that the process will be an important adjunct in water analysis.

Mr. Rowland suggested the determination of suspended matter as advisable.

In regard to the Kensington district Dr. Wahl referred to the extensive use of well water as the probable cause of much sickness.

Dr. Tuttle remarked on the advisability of analyzing the water of suspected wells.

The President called attention to a number of cases of typhoid fever which occurred in one family, and which were clearly traceable to contaminated well water and unsanitary conditions in the dwelling-house.

Dr. Samuel C. Hooker read a paper "On the Occurrence of Lapachic Acid in Bethabarra Wood," giving the results of an investigation undertaken in conjunction with Dr. Wm. H. Greene. The authors have unquestionably established the identity of the yellow principle of the Bethabarra wood with lapachic acid. A number of beautiful specimens were exhibited, both of the acid and of compounds prepared from it. One of the most interesting of these, lapachone, will be made the subject of further study, as the constitution which has been assigned to it is not in accordance with many new reactions observed. The results so far obtained point very strongly to the conclusion that lapachone is a derivative of naphto-furfuran and has the formula

$$C_{10}H_4 \begin{cases} O_2 \\ CH_2 \\ O \end{cases} \rangle\!\!\rangle\, CH.C_3H_7$$

The opinion was also expressed that the compound prepared by Paternò, and considered by him to be brom-lapachic acid is in reality brom-lapachone having the formula

$$C_{10}H_4 \begin{cases} O_2 \\ CH\,(Br) \\ O \end{cases} \rangle\!\!\rangle\, CH.C_3H_7$$

Dr. Smith and Mr. Frankel presented a paper on the electrolytic separation of mercury and copper, which was submitted for printing and distribution among the members, and was referred for publication.

Dr. Smith also stated that in the electrolysis of nickel and cobalt, in a solution containing potassium cyanide in excess, cobalt does not separate out, but whether these metals can be separated by this means remains to be seen.

Dr. Wahl showed some specimens of decorated glass in which the ornamentation was the result of coating a colored or flashed glass on one side with glue or gelatine, and then drying this in a current of air; the gelatine in drying contracts with sufficient force to tear away portions of the surface of the glass, thus producing striking and beautiful effects.

Adjourned. WM. C. DAY, *Secretary.*

On the Occurrence of Lapachic Acid in Bethabarra Wood.

By Wm. H. Greene and Samuel C. Hooker.

[*Read at the Meeting of the Chemical Section, April 16, 1889.*]

A few weeks ago we were asked by Mr. A. B. Shipley, of this city, a large importer of Bethabarra wood, to investigate the properties of a yellow substance with which the pores of the wood appear to be filled. So far as we know, the wood is used in this country for the manufacture of bows and fishing-rods only, for which purpose it is admirably adapted, on account of its great tenacity and remarkable elasticity.

We have been able to learn nothing of the botanical nature of the tree yielding the Bethabarra wood, which is said to be brought from the West Coast of Africa, but we believe that we may venture the opinion that it is a species of Lapacho. The latter is one of the finest ornaments of the sub-tropical hills and plains of South America. Its far spreading branches are in the spring covered with masses of flowers, red or yellow, according to the variety, so dense that the rays of the sun cannot penetrate them. Its wood is very hard, susceptible of a fine polish, and resists indefinitely the action of moisture.

The considerable cost of the wood made it desirable that, if possible, some use should be found for the refuse.

A few preliminary experiments with the extracted substance showed us that it contained a compound of much scientific interest, and for this reason we felt justified in undertaking the research, independently of any pecuniary result with which we were not concerned.

On referring to the literature of the subject, we found a paper entitled "Preliminary Notice of a New Vegetable Coloring Matter," published by Samuel P. Sadtler and William L. Rowland in December, 1880,* concerning the principle of the Bethabarra wood. Aside from analyses,

* *Amer. Chem. Jour.*, **3**, 22.

this paper throws but little light on the constitution and properties of the substance, dealing mainly with a comparison of the color reactions of the Bethabarra principle with crysophanic acid, santalin, hæmatoxylin and brasilin. The analyses of the authors left them undecided between the formulæ $C_{28}H_{29}O_5$ and $C_{22}H_{23}O_4$, and they conclude their paper with a suggestion that a close relationship exists between the Bethabarra principle and crysophanic acid and hæmatoxylin.

The Bethabarra wood used in our investigation was mainly in the form of sawdust. This was extracted in quantities of about five kilogrammes at a time by percolation with a cold one per cent. solution of crystallized sodium carbonate; the solution was allowed to remain in contact with the wood for several hours, and then drawn off, and the operation was repeated three or four times until the intensity of the deep red color of the extract was much diminished. The liquid was then treated with an excess of hydrochloric acid, and the precipitate allowed to settle, the excess of acid being necessary to insure the rapid separation of the precipitate. The clear liquid was then siphoned off, and the precipitate collected on a filter and dried.

This extract consists of the crystalline principle of the wood, accompanied by a resin, and as both are readily soluble in alcohol, this is not a desirable agent for the first crystallization as recommended by Sadtler and Rowland. On the other hand, we found the resin to be practically insoluble in ether, which freely dissolves the crystalline substance. The dry substance was broken up and shaken with ether in a closed flask; the addition of a few drops of water causes the resin to agglomerate and adhere to the walls of the flask; the ethereal solution could then be poured off without filtration. This operation was repeated with fresh ether; the ether distilled off, and the crystalline mass obtained was thrown on a filter and washed with a little alcohol at the pump. In this way the substance was obtained in a nearly pure condition, one recrystallization from alcohol yielding an absolutely pure product equal in quantity to at least 0·6 per cent. of the wood employed.

After a brief examination of our substance, we were struck by the remarkable similarity of its properties with those of taiguic acid,* which will be found described in Gmelin's Hand-Book, xvi, 521, and which has been shown by Paternò† to be identical with the greenhartin of Stein‡ and with the lapachic acid of Siewert.§ Under the latter name, this substance has been the subject of an admirable research by E. Paternò,‖ who from a series of concordant analyses deduced the formula $C^{15}H^{14}O^3$, and was able to assign to it with great probability the constitution of an amylene-oxynaphthaquinone.

$$C_{10}H_4\begin{cases} CH = CH - CH(CH_3)_2 \\ O \\ OH \end{cases}$$

A close examination of the Bethabarra principle established its complete and unquestionable identity with lapachic acid. Its fusing point is 139°·5–140°·5; that of lapachic acid, as given by Paternò, is 138°.

We have prepared a number of characteristic salts. That of ammonia is unstable, losing ammonia with great readiness; a dilute solution of this salt deposits crystals of the acid when evaporated, as observed by Paternò with the ammonium compound of lapachic acid.

The silver salt is obtained as a bright red amorphous powder; on analysis we obtained the following figures:—

I. 0·2594 gr. gave 0·0795 gr. silver.
II. 0·2674 " " 0·0830 " "

	Found.		*Calculated for* $C^{15}H^{13}O^3Ag$.
	I.	*II.*	
Ag	30·65 per cent.	31·04 per cent.	30·95 per cent.

Mean of analyses by Paternò, 30·87 per cent. Ag. Analyses I and II were of compounds prepared separately.

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* *Comptes rendus*, **46**, 1,152.

† *Gaz. Chim. Ital.*, 1879, **9**, 505.

‡ *Jour. prak. Chemie*, **99**, 1.

§ *La République Argentine*, par R. Napp, aidé de plusieurs collaborateurs. Ouvrage écrit par ordre du Comité central Argentin pour l'Exposition de Philadelphia. Buenos Ayres, 1876.

‖ *Gaz. Chim. Ital.*, **12**, 337–392.

By reducing agents the Bethabarra principle is converted with great facility into a white crystalline substance, which rapidly absorbs oxygen from the air, being reconverted into the original compound. This also characterizes lapachic acid.

By the action of concentrated sulphuric acid we have obtained a beautiful orange-red, quinone-like, crystalline substance, fusible at 155°–156° and identical with lapachone.* Concentrated nitric acid in the cold gives rise to the same substance, as shown by Paternò.

As the unexpectedly rapid result of our research has left us sufficient material to extend our investigations, and as the constitution assigned by Paternò to lapachone is not in accordance with some reactions which we have observed, we purpose to make this compound the subject of further study.

PHILADELPHIA, 10th April, 1889.

ON THE PRESENT CONDITION OF THE PHILADELPHIA WATER SUPPLY. FIRST MONTHLY REPORT

By SAMUEL C. HOOKER, Ph.D.

[*Read at the Stated Meeting of the Chemical Section, April 16, 1889.*]

Many considerations have induced me to undertake a systematic and frequent chemical examination of the water supplied to this city, and at the outset it would seem desirable that I should briefly enumerate some of the principal reasons for the investigation, and mention some of the beneficial results which it is to be hoped may arise from it. In approaching this question of the water supply of Philadelphia, which has given rise to so much discussion and difference of opinion, I desire it to be understood that I am primarily seeking for information, and that I wish to ascertain as nearly as possible the condition of the water at *all* times. We hear occasionally when the water is bad, but we

* Paternò, *loc. cit.*, 372.

do not hear when it is good. We should be acquainted with the good as well as with the bad aspect of the case, and deal with the question in a fair and unprejudiced manner. With the advantages offered by the large subsiding basin in the East Park, and with increased care in the prevention of the access of foul matter to the Schuylkill River, we should ask ourselves whether the condition of the water has so improved as to render it generally good, and to leave the times at which it may be seriously open to suspicion so few and far between as to make them of comparatively small importance. This is a question which can only be answered by a thorough and systematic examination such as I have commenced. Isolated analyses of samples purposely taken at times when everything conspires to make the water unusually bad, are of comparatively small value. Indeed, the information they give is such as to be positively misleading and to urge the belief that the water is at all times far worse than is really the case.

At the time my investigations were commenced the water was not systematically analyzed at regular and frequent intervals, and such analyses as were fitfully made, were not accessible to the public. The last published reports of the Water Department and also of the Health Department do not contain a single analysis, a fact which speaks more strongly than any other for the needs of such work as I have undertaken. The very unfavorable opinion to which—rightly or wrongly—some of the best known experts who have examined into the matter have come, regarding the condition of the Schuylkill River in the past, renders it highly desirable that the water supplied to the city should at all times be under chemical supervision. The interests of the public demand it. In the case of a river which is liable to pollution, it is obvious that circumstances may arise to make the water at times more than ordinarily dangerous. By frequent chemical examinations such a condition of the water would be detected at once, the public could be warned of it, and steps taken to find and remove, or at least mitigate the cause of the trouble. It is, therefore, extremely desirable that the water should be very frequently

analyzed, both for the information and protection of the public.

Aside from throwing some light on the question of wholesomeness, it is to be hoped that the present investigation may arouse public interest, with the view to pushing forward such improvements as will be instrumental in securing a *cleaner* supply.

In the face of such difference of opinion as exists regarding the wholesomeness of the Schuylkill, it is certainly satisfactory to find one point upon which all are agreed, and which does not admit of contradiction or argument. For whether the water be wholesome or unwholesome, whether it be charged with sewage or free from such contamination, whether it be loaded with or free from disease, it cannot be denied that the muddy condition of the water very frequently supplied to certain sections of the city, and at intervals to others, is a great and ever increasing disgrace to the city of Philadelphia.

The samples of water for analysis are drawn every Friday morning from six sections of the city, which have been carefully selected, so as to include all the probable variations in condition which the supply may simultaneously present at different portions of the city. This refers only to the water from the Schuylkill.

The samples are collected in the following neighborhoods:

(1) Sixteenth and Locust.
(2) Front and Bainbridge.
(3) Forty-fourth and Chestnut.
(4) Beach and Vienna.
(5) Twentieth and Columbia Avenue.
(6) 4000 Germantown Avenue.

(1) The first of these localities is usually supplied from the Spring Garden pumping station through the Corinthian Avenue basin. It may also be supplied from the Fairmount, Spring Garden and East Park reservoirs. The water at this point represents the supply of the district between Vine and South Streets.

(2) The city below South Street is fed by the Fairmount pumping station through the Fairmount reservoir. This part of the city may also be supplied in case of necessity from the Corinthian Avenue basin.

(3) The sample drawn at Forty-fourth and Chestnut is representative of the whole of West Philadelphia. The water is pumped at the Belmont Station and supplied through the Belmont reservoir.

(4) Kensington, in which Beach and Vienna is situated, formerly received its supply from the Delaware. Since the middle of September, 1888, Schuylkill water has been fed to this district. In future it is proposed to pump Delaware water only in the case of emergency.

(5) The water drawn at Twentieth and Columbia Avenue represents that of the whole of the Northwestern portion of the city. This district, which is bounded on the north by Allegheny Avenue, on the south by Vine Street, and on the east by Broad Street, is supplied by direct pumpage from the Spring Garden works.

(6) The Twenty-second and part of the Twenty-eighth Wards are supplied from the Mt. Airy reservoir, which is fed from the Roxborough Station. The water drawn at Germantown Avenue represents this district.

By thus collecting the water as actually supplied to the city instead of taking it directly from the river or the reservoirs, not only are fairer samples obtained, but the water should be at its best, having had the advantage of passing through the subsiding basins.

It is to be hoped that as improvements are made a careful study of these reports will lead to those sections of the city which are at present worst off being first considered.

Although a lengthy discussion of the methods of analysis is unnecessary, it may be well briefly to mention the processes employed.

The determinations of albumenoid and free ammonia were made in all essential particulars as recommended by Wanklyn. Duplicate analyses, occasionally made to test the accuracy of the results, gave figures so closely cor-

responding to the first determinations as to leave little to be desired.

The chlorine was estimated by the well-known volumetric process. The greatest possible care was taken with these determinations, as very slight variations appear of considerable importance. Duplicate determinations were made in every case and the mean of at least two experiments taken. The nitrates were determined by the carbazol process, devised by myself, and already described in detail to the Section.

The following table gives the results obtained:

ANALYSIS OF THE PHILADELPHIA WATER SUPPLY.

Kensington, Beach and Vienna.

Date. 1889.	*Chlorine.*	*Free Ammonia.*	*Albumenoid Ammonia.*	*Nitrogen of Nitrates.*
March 15th,	·32	·0005	·0055	·14
" 22d,	·32	·0005	·0050	·14
" 29th,	·38	·0005	·0065	·12
[April 5th,	·51	·0075	·0190	·07]
" 12th,	·34	·0005	·0070	·10
Average, omitting the sample of April 5th, as from the Delaware,	·34	·0005	·0060	·125

West Philadelphia.

March 15th,	·30	·0025	·0045	·14
" 22d,	·15	·0020	·0050	·14
" 29th,	·27	·0025	·0070	·11
April 5th,	·27	·0020	·0075	·10
" 12th,	·31	·0010	·0065	·10
Average,	·26	·0020	·0061	·118

Sixteenth and Locust.

March 15th,	·27	·0000	·0105	·14
" 22d,	·24	·0000	·0070	·14
" 29th,	·35	·0015	·0075	·12
April 5th,	·26	·0015	·0080	·11
" 12th,	·35	·0010	·0085	·10
Average,	·29	·0008	·0083	·122

Front and Bainbridge.

Date. 1889.	*Chlorine.*	*Free Ammonia.*	*Albumenoid Ammonia.*	*Nitrogen of Nitrates.*
March 15th,	Sample not forwarded.			
March 22d, ...	·32	·0005	·0075	·14
" 29th, ...	·36	·0005	·0055	·12
April 5th, ...	·28	·0010	·0070	·10
" 12th, ...	·35	·0010	·0090	·09
Average, ...	·32	·0007	·0072	·112

Twentieth and Columbia Avenue.

March 15th, ...	·30	·0000	·0070	·13
" 22d, ...	·35	·0005	·0100	·14
" 29th, ...	·37	·0020	·0085	·11
April 5th, ...	·26	·0015	·0140	·11
" 12th,	Demijohn broken in transit.			
Average, ...	·32	·0010	·0098	·122

4000 Germantown Avenue.

March 15th,	Sample not on time.			
" 22d, ...	·25	·0005	·0110	·12
" 29th, ...	·30	·0005	·0165	·11
April 5th, ...	·26	·0015	·0125	·10
" 12th,	Sample not on time.			
Average, ...	·27	·0008	·0133	·110

All the above results are expressed in parts per 100,000.

It will be apparent to any one at all familiar with the subject, that the worst feature of these analyses lies in the comparatively large amount of nitrates. Apart from this, the condition of all the samples examined from the Schuylkill—twenty-four in number—is very satisfactory, and if maintained throughout the year, would render any serious anxiety as to the wholesomeness of the supply quite unnecessary. It is certainly gratifying to find the condition of the water so uninterruptedly satisfactory during a whole month, and so much better than one could have fairly expected from the pessimistic reports which have recently from time to time been published in the newspapers. It will be understood that I am at present speaking of the

quality of the water without reference to its muddiness. With regard to this latter particular, the condition of all the water could not by any means be said to be satisfactory.

It will be observed that the sample drawn at Beach and Vienna on April 5th, was vastly inferior to the remaining samples collected at the same locality on other days, and also to the other samples collected at other points on the same date. Although I had information that Kensington was drawing its water from the Schuylkill I could not believe that this was really the case at the time that this particular sample was drawn. I consequently made a personal visit to the Kensington Water Works, on April 11th, to clear up the matter, and was gratified to find that my surmise was correct. The pump at the works was drawing water from the Delaware at that date, and had been doing so since April 3d, on account of a breakdown at the Spring Garden Station.

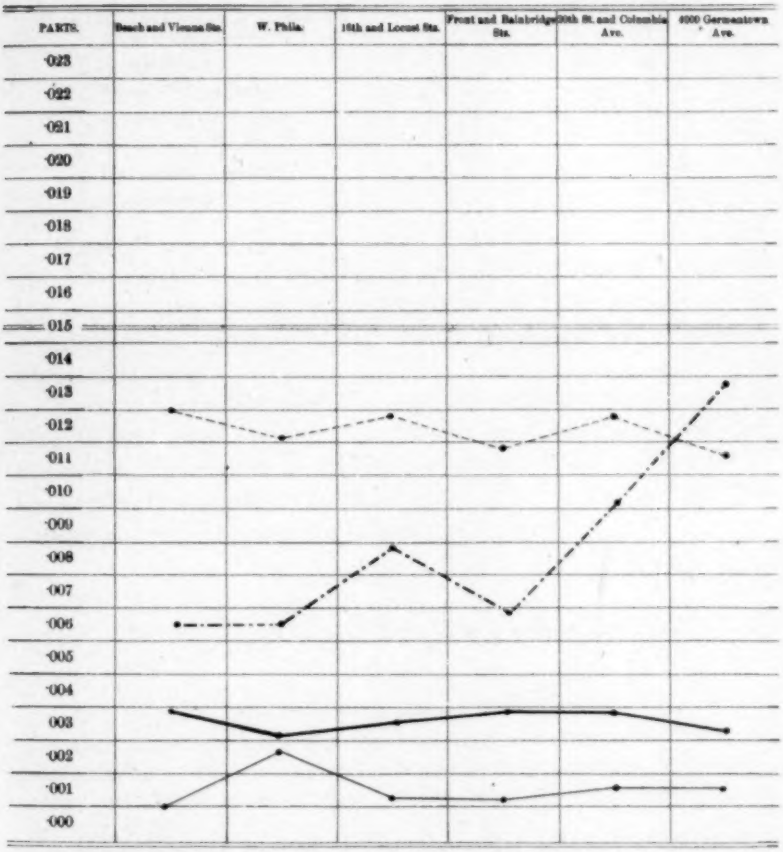
Pumping from the Delaware, at the Kensington Works, still continues at the present date, but the Lehigh basin, into which the water is forced, is apt to be low towards the evening, at which time the overflow from the Spring Garden basin is permitted to flow into it. Samples collected in the early morning may, therefore, consist almost entirely of Schuylkill water. This explains the good condition of the water from this district on April 12th, and its very great similarity to the samples drawn previous to April 3d.

From an examination of the table it will be observed that on the whole the quality of the water in each locality has been very uniform doing the past month. There is, however, a marked difference in some respects in the water from the different localities. For instance, the free ammonia is almost constantly higher in West Philadelphia than in other portions of the city, and similarly the albumenoid ammonia is higher in Germantown than elsewhere. Should these differences be maintained, they will be fully considered in detail in subsequent reports.

My observations so far show that the albumenoid ammonia is greater in the turbid samples, even after filtration through paper, than in the clearer ones, or in other words that the

DIAGRAM SHOWING THE AVERAGE RELATIVE CONDITION OF THE WATER SUPPLY AT DIFFERENT POINTS OF THE CITY. March 15 to April 12, 1889.

(CONSTRUCTED FROM 24 ANALYSES.)



EXPLANATORY NOTES:

Nitrogen of Nitrates in parts per 10,000.
Representing, when in excess, animal matter, which by natural processes of purification has been rendered harmless.

Albuminoid Ammonia in parts per 100,000.
Representing, when in excess, nitrogenous organic matter of the most dangerous type.

Chlorine in parts per 1,000.
Representing, when in excess, present or past sewage contamination.

Free Ammonia in parts per 100,000.
Representing, when in excess, decaying organic matter.

Provided that the two lower curves do not vary much in height from those given, the condition of the water may be regarded as satisfactory, so long as the two upper curves remain below the double line through ·015.

It will be understood that the smaller the quantity of the substances indicated by the above curves, the more satisfactory the condition of the water. In other words, the water is most satisfactory with regard to each particular substance, at the lowest point of each curve.

albumenoid ammonia is in some degree proportional to the turbidity.

This is well shown in the following table:

Average order of turbidity for the month. The water from the first locality being the best, i. e., the brightest.	*Average of albumenoid ammonia for the same period.*
1. Kensington,	·0060
2. West Philadelphia,	·0061
3. Sixteenth and Locust,	·0083
4. Front and Bainbridge,	·0072
5. Columbia Avenue,	·0098
6. Germantown,	·0133

The full meaning of this, which has, I believe, considerable bearing on the quality of the Germantown water as compared with that of other localities, will be considered in a subsequent report when the data collected have become somewhat larger.

As it is intended that the results of these analyses may clearly and readily be understood by those who are not chemists, a diagram is appended, which it is believed will be made thoroughly intelligible to all by the aid of the explanatory notes accompanying it.

SCIENTIFIC NOTES AND COMMENTS.

MECHANICAL ENGINEERING.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.—In September, 1888, Dr. John Hopkinson, Mr. Beauchamp Tower and Prof. Alexander B. W. Kennedy carried out a series of motor trials for the Society of Arts (*Journal of the Society of Arts*).

The motors tested were a Crossley (Otto) nine nominal horse-power, a Griffin eight nominal horse power, and an Atkinson six nominal horse-power, all gas engines, and a Davey-Paxman compound portable steam engine of eight nominal horse-power. The judges awarded a gold medal to the Paxman and to the Atkinson engines, as they were each the sole representatives of a class, and had each given exceptionally good results. In the cases of the other engines, the Crossley had the advantage as to economy of gas and lubricant, and the Griffin in respect to regularity of speed, and a gold medal was awarded each.

The trials consisted of an efficiency test of six hours duration for each engine, a three hours' run at half power, a test running light, and other tests

made at the request of the exhibitors, under conditions different from the competitive conditions.

The methods of the trials were generally as follows: The gas used in the engine and for ignition was measured separately, wet meters being used, and readings taken every quarter of an hour. The pressure and temperature of the gas were measured in the meter, and samples of the gas taken for analysis. Indicator diagrams were taken every quarter of an hour. The springs were tested and the errors found to be very small. Rope brakes were used for absorbing the power. The water fed to cylinder jackets was metered and its temperature taken. The number of revolutions were taken from a continuous counter, read every fifteen minutes simultaneously with the reading of the gas meters. The number of explosions was determined.

The steam engine was tested in practically the same way, the coal burned and water evaporated were weighed, the indicator cards and revolutions taken as in the gas engine trials. The power was absorbed by a rope friction brake, but, instead of trusting to the air cooling the wheel, water was allowed to drip into the trough inside the rim and evaporate out. The cylinders were fitted with jackets, but the exhibitor elected to run without them. In all cases the quantity of lubricator fed to the cylinder was measured. The following are the principal dimensions of the engines tested:

Crossley.—9·5 inches diameter cylinder, 18 inches stroke. One fly-wheel 5 feet 5½ inches diameter, 9 inches face, weighing 1,652 pounds. Fitted with countershaft for running dynamos.

Griffin.—9·02 inches diameter cylinder, 14 inches stroke. Two fly-wheels 60·1 inches diameter, 7·5 inches face, each weighing 1,144 pounds. The piston-rod 1·75 inches diameter.

Atkinson.—9·5 inches diameter cylinder, suction stroke 6·33 inches, compression 5·03 inches, working 11·13 inches, and the exhaust stroke 12·43 inches. Radius of crank, 12⅞ inches. Two fly-wheels 69·3 inches diameter, 4·5 inches face, each weighing 1,462 pounds.

Paxman Portable.—Boiler of locomotive type. Engine, compound horizontal cylinders, 5·24 inches and 8·98 inches diameter by 14 inches stroke. One fly-wheel 62 inches diameter, 7⅜ inches face and weighing 910 pounds.

The following tables show the results of the full and half power trials. In estimating the gas per brake horse-power for the Crossley engine, the power to run the countershaft was omitted, and taking this into consideration gives 27·4 cubic feet of gas per net horse-power available for outside work. The results of the second trial with the steam engine are given here. As in the first one, some exhaust steam was returned to the feed-tank, and the amount could not be determined.

FULL POWER TRIALS.

	Atkinson.	Crossley.	Griffin.	Paxman.
Duration, hours,	6	6	6	6·27
Revolutions per minute,	131·1	160·1	198·1	137·35
Explosions " "	121·6	78·4	129·0	
Mean initial pressure, pounds,	166·0	196·9	132·3	H.P. 176·8
Mean effective pressure, pounds,	46·07	67·9	54·15	H.P. 54·98 L.P. 16·78
Indicated horse-power,	11·15	17·12	15·47	H.P. 11·30 L.P. 10·26 21·36
Brake load, net, pounds,	130·5	177·4	130·7	288·0
Brake horse-power,	9·48	14·74	12·51	18·95
Mechanical efficiency,	·85	·861	·809	·879
Gas per hour, main, cubic feet,	209·8	351·8	350·2	. . .
" " " ignition,	4·5	3·5	7·1	. . .
" " " total,	214·3	355·3	357·3	. . .
Gas per i. h. p., per hour, main,	18·82	20·35	22·64	. . .
" " " " total,	19·22	20·76	23·10	. . .
Gas per b. h. p., per hour, main,	22·14	23·87	28·00	. . .
" " " " total,	22·61	24·10	28·36	. . .
Water per hour, pounds,	680·	713·	1022·	. . .
Rise in temperature,	50°·2	128°·0	71°·8	. . .
Horse-power in driving engine	1·67	2·38	2.96	2·61
Mean pressure during working stroke equivalent to work done in pumping stroke about, pounds,	1·00	2·19	2·40	. . .
Corresponding i. h. p.,	·26	·55	·69	. . .

HALF POWER TRIALS.

	Atkinson.	Crossley.	Griffin.	Paxman.
Duration, hours,	3	3	3	3·12
Revolutions per minute,	129·6	158·8	201·8	138·10
Explosions " "	69·1	41·1	82·6	. . .
Mean initial pressure,	166·5	196·2	135·1	H.P. 113·0
Mean effective pressure,	47·60	73·4	55·85	H.P. 33·25 L.P. 8·92
Indicated horse-power,	6·59	9·73	10·23	H.P. 6·85 L.P. 5·47 12·32
Brake load, net,	66·0	89·9	64·67	147·6
Brake horse-power,	4·74	7·41	6·30	9·76
Mechanical efficiency,	·719	·762	·616	·792
Gas per hour, main,	127·1	202·6	228·7	. . .
" " " ignition,	5·9	3·2	5·8	. . .
" " " total,	133·0	205·8	234·5	. . .
Gas per i. h. p., per hour, main,	19·29	20·8	22·35	. . .
" " " " total,	20·18	21·2	22·92	. . .
Gas per brake horse-power, main,	26·80	27·34	36·30	. . .
" " " total,	28·10	27·77	37·20	. . .
Water per hour, in pounds,	260·	480·	616·6	. . .
Rise in temperature,	67·8	102·3	71·31	. . .
Horse-power in driving engine,	1·85	2·31	3·93	2·56

BOILER.

	Full Power.	Half Power.
Boiler pressure, absolute,	202·78	134·9
Temperature, steam,	382·9	350·1
Pounds of feed water, per hour,	447·1	392·2
" " " i. h. p.,	20·74	26·72
" " " b. h. p.,	23·59	33·73
Mean temperature, feed,	63°·0	69°·9
Temperature of gases, Fahr.,	304°·4	369°·1
Coal per hour*, pounds,	40·70	27·25
" " " per i. h. p.,	1·89	2·21
" " " " b. h. p.,	2·15	2·79
Pounds water per pound coal,	10·99	12·08
" " from and at 212°,	11·71	12·76

In the reports of the trials, tables are given showing approximately the percentage of the available heat turned into work, rejected in jacket water, and rejected in the exhaust, radiation, etc. During the full power trials, in the Atkinson engine, of 13,280 heat units available per explosion, 25·5 per cent. was converted into work and twenty-seven per cent. rejected in the jacket water. In the Crossley test of 34,040 heat units available 22·1 per cent. was converted into work and 43·2 per cent. was rejected in the jacket water. In the Griffin trial of 20,650 available heat units 21·1 per cent. was converted into work and 35·2 per cent. rejected in the jacket water. In the steam engine of 577,900 heat units available per hour 9·6 per cent. was converted into work. In the boiler, during the full power trial, of 577,900 heat units available, 79·65 per cent. was expended in heating and evaporating the water, 7·05 per cent. in raising the temperature of the furnace gases, 8·85 per cent. was lost by radiation, 2·68 per cent. by imperfect combustion, ·10 per cent. in evaporating the moisture in the coal and 1·67 per cent. was unaccounted for.

It is to be regretted that there were not more engines entered for trial. The work done in carrying out these trials is of the very best character, and the results are a considerable addition to our stock of knowledge.

The report contains many other data in addition to that given above and is well worth studying. H. W. S.

BOOK NOTICES.

FRICTION-BRAKE DYNAMOMETERS.—William Worby Beaumont, M. Inst. C. E. With an Abstract of the Discussion on the Paper. From Minutes of Proceedings of the Institution of Civil Engineers. Vol. xcv. Session 1888–89. London.

The paper is a description of the various forms of friction brakes modelled on the Prony brake, and treats of the inaccuracies of the methods of measuring and the reliability of the results obtained from them.

* Calorific value, 14,200 thermal units per pound, no reduction being made from the hydrogen for the oxygen present.

In the original Prony brake, the author states that for measuring the power of a motor at uniform speed and constant load, the inaccuracy of its indications may be very small and often insignificant. The necessity of changing the tension on the brake strap to maintain the load constant, makes a self-regulating dynamometer greatly to be desired.

The compensating brake of M. Deprez, suitable for small powers, is described. In this the compensation takes place slowly and adjustments have frequently to be made.

A simple form of self adjusting dynamometer, made by Mr. J. Imray, is described and several forms of brakes, with Appold's compensating lever, are described. Numerous other special forms are treated of in the paper and in the discussion following it.

An attempt is made to determine the proportion of brakes from several successful examples, but beyond giving the dimensions of brakes in use is of no especial importance.

In the paper and discussion numerous rope brakes were spoken of, which for ease of construction and use will compare favorably with the more elaborate forms spoken of. Professor Kennedy, one of the conductors of the motor trials for the Society of Arts, described the apparatus used in these tests.

A hemp rope or a couple of ropes, one and three-quarter-inch circumference, passing around the wheel once, was weighted at one end and attached to a spring balance at the other. A wheel, five feet in diameter, seven inches face, weighing 910 pounds, running at 140 revolutions per minute, took nineteen and one-half brake horse-power without trouble. Water dripped into the trough on the inside of the rim and evaporated out.

The entire paper is a fair account of the various devices in use for absorbing power, and in the discussion there is considerable difference of opinion as to their relative advantages. H. W. S.

A Treatise on Hydraulics. By Mansfield Merriman. 8vo. John Wiley & Sons, New York, Publishers.

This timely production adds another to the many works on this important subject, and yet there is room. The reputation of this well-known author for thoroughness will at once commend this book to the student as a valuable accession. A brief review of its contents shows that it is prepared with reference to modern requirements. They cover such topics as hydrostatics; theoretical hydraulics; flow through orifices, over weirs, through tubes, in pipes, conduits, canals and rivers; measurement of water-power; dynamic pressure of flowing water; hydraulic motors and naval hydromechanics; all of which are included in 381 pages of attractive typography. The demonstrations are treated, in general, analytically and in some instances with the aid of calculus, so that the book is limited to those familiar with the pure mathematics, although there are many deductions and general principles of use to the practical hydraulician.

In a treatment so condensed of so extended a subject matter, many

important sub-divisions must necessarily have been greatly abridged, as, *e. g.*, those relating to the stability of flotation, back-water, dams, tidal energy, and waves, some of which acquire great practical importance to the maritime and hydraulic engineer.

The question of the position of the metacentre is of much more frequent application in engineering construction than in the construction of ships, and acquires importance in the various form of caissons for sub-marine foundations built on shore and floated to their proposed sites. The entire question of masonry dams is disposed of by giving the general equation of equilibrium, with an example, all included in less than two pages.

Usually but one problem is required to illustrate a principle, and that without the answer. We believe it better to state the result, that the student may be able to check his work, and so increase his confidence in his ability to solve similar cases.

In the numerous references which are stated in the foot-notes, it would also appear to be more satisfactory, to those wishing to consult the authorities, to have a specific address, either of the publisher or of a depository, where the work may be found. Thus we find, "Smith's Hydraulics, p. 176," "Del Moto dei Gravi (Firenz, 1644)," etc.

The most important omission, however, is the absence of a topical index, arranged alphabetically. This is but poorly supplied by the table of contents, moreover we must take exception to the statement made on the closing page, that "upon the ocean, waves move in the same direction as the wind, but along shore it is observed that they move normally towards it, whatever may be the direction in which the wind is blowing," as being contrary to the fact, since the well-nigh universally received opinion as to the motion of waves (breakers) on shore is curvilinear, being retarded at the shore line, and breaking at a prevalent if not a permanent angle, which is determined rather by the form of the fore-shore than by the direction of the wind. This is an important phenomenon, and accounts for the travelling of the beaches and inlets in a prevalent direction, and furnishes the key to the solution of many harbor problems.

Space will not permit us to call attention to the many good features of the work, which will commend itself to instructors and students alike for the clearness and logic of its demonstrations. H.

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Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, April 17, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 17, 1889.

JOSEPH M. WILSON, President, in the Chair.

Present, 162 members and thirty-four visitors.

Additions to membership during the past month, 104.

By direction of the Board of Managers, the Actuary presented the following report of the condition of the Elliott Cresson Medal Fund, prepared and submitted by Mr. FREDERICK FRALEY, trustee of the fund, viz:

NO. 1000 WALNUT STREET,
PHILADELPHIA, April 8, 1889.

DEAR SIR:—A short time ago Mr. Heyl, the Actuary of the FRANKLIN INSTITUTE, called on me and stated that the managers desired to have a statement of the present amount of the Elliott Cresson Medal Fund, and also whether it would not be advisable to have an additional trustee of the fund appointed, in place of Mr. John Wiegand, who died some years ago. It gives me great pleasure to comply with these requests.

The fund was created by Mr. Elliott Cresson in the year 1848, and the capital of endowment was a certificate for $1,000 in the loan of the Schuylkill Navigation Company of the year 1845. The loan was then considerably below par, and no interest was paid on it for several years, owing to the unfavorable state of the finances of the company, and the disastrous results of the great flood on the Schuylkill River in 1850. When the Schuylkill Navigation Company's affairs were adjusted in 1852, the original certificate of fund and the arrears of interest thereon was converted into a certificate of the loan of 1882 for $740, and ten shares of prefered stock of the par value of $500, thus making the nominal capital of the fund, $1,240. The interest and dividends received on this sum and the accumulation thereof have been sufficient to pay for the dies for the medals, and the medals struck and delivered to the INSTITUTE, and to leave a balance to the credit of the fund, April 1, 1889, of $3,943.11, which consists of a certificate of loan of the City of Philadelphia for $1,700, deposit in the Western Saving Fund of $1.973.96, and cash in my hands of $269.15. When the affairs of the Philadelphia and Reading Railroad were reorganized, in 1887, the loan and preferred stock of the Schuylkill Navigation Company belonging to the fund were deposited under the plan, and converted to the

new Reading securities, which were sold and produced $548.64. This sum I believe is more than the original $1,000 of Schuylkill Navigation loan was worth in the market when the fund was created.

The dies for the medals are at the United States Mint in Philadelphia, and all the medals have so far been struck there.

I find by reference to the trust deed that whenever a vacancy occurs by the death or resignation of a trustee, his place is to be filled by an election to be made by the FRANKLIN INSTITUTE, at a stated meeting after due notice. I had not read the deed for many years, or I should have called the attention of the INSTITUTE to this matter immediately after the death of Mr. Wiegand. You have a copy of the deed in the minute-book, and from it will see how the election of a new trustee is to be made.

With my best wishes for the welfare and prosperity of the INSTITUTE of which I have been a member for sixty-four years, I am,

Sincerely yours,

FREDERICK FRALEY.

To JOSEPH M. WILSON, ESQ.,
President FRANKLIN INSTITUTE.

The Secretary reported the resignation of Mr. MOSES G. WILDER as a member of the Committee on Science and the Arts. The resignation was accepted and Mr. JOHN E. CODMAN was elected to fill the vacancy.

The Special Committee to Increase Membership made a report of progress, and was continued.

The Actuary further reported a recommendation from the Board of Managers, that Prof. LEWIS M. HAUPT (civil engineer), Mr. CARL HERING (electrical engineer) and Mr. F. LYNWOOD GARRISON (metallurgist), members of the INSTITUTE, who had expressed their willingness to act as representatives and to report upon subjects within their respective specialties, be appointed as delegates to the International Exhibition in Paris.

The recommendation was approved and the President and Secretary were authorized to issue a suitable document attesting the fact over their signatures and the seal of the INSTITUTE.

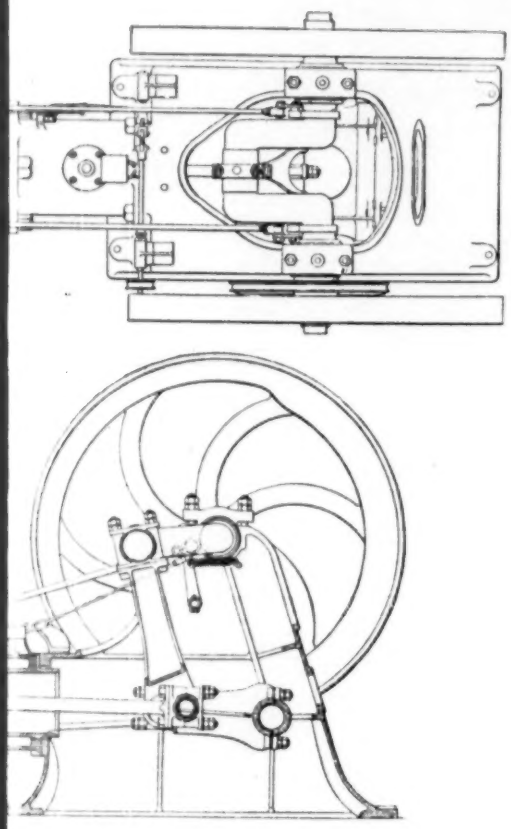
Mr. WM. B. LE VAN read a paper on "High Railway Speeds," illustrating it with the aid of lantern slides. The subject embraced substantially a comparison of English and American locomotives and rolling stock. (Referred for publication.)

Capt. E. L. ZALINSKI, U. S. A., presented an oral communication, supplementing his remarks at the March meeting, by a description of the U. S. cruiser *Vesuvius*, with lantern illustrations.

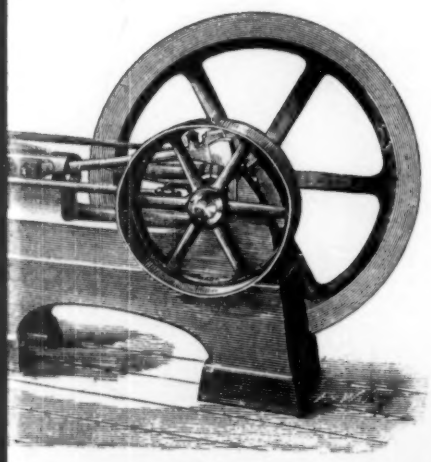
The Secretary's report embraced a description, with illustrations, of the proposed suspension bridge over the Hudson at New York, designed by Mr. GUSTAV LINDENTHAL, and an abstract of the report of the Committee on Science and the Arts on OTIS C. WHITE'S "Adjustable Extension Movement in Ball and Socket Joints," of which invention a fine suite of specimens was exhibited.

Adjourned.

WM. H. WAHL, *Secretary*.



evation and Indicator Diagram.



lerk's Gas Engine 1881.

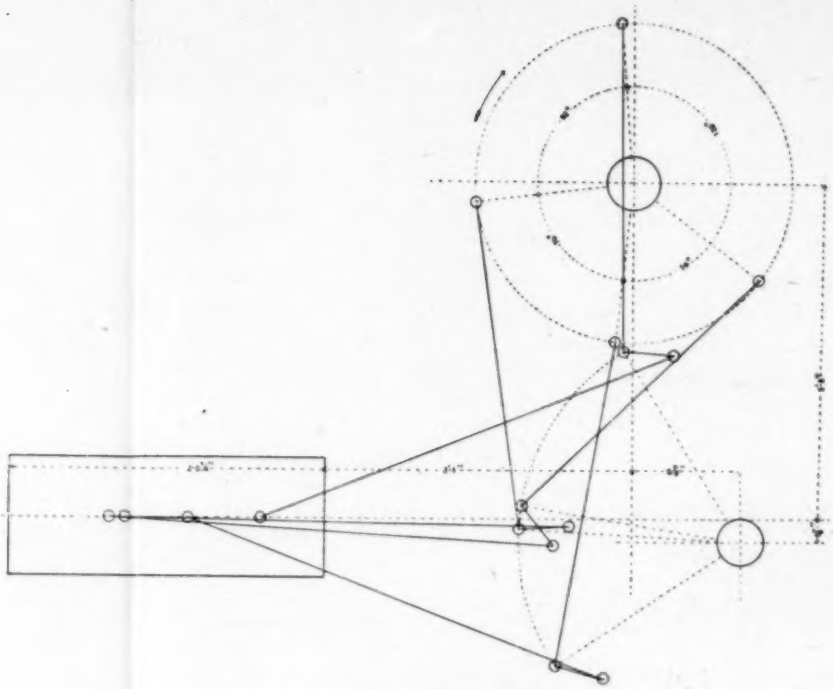


Fig. 24.—Skeleton Diagram of Atkinson's Gas Engine.

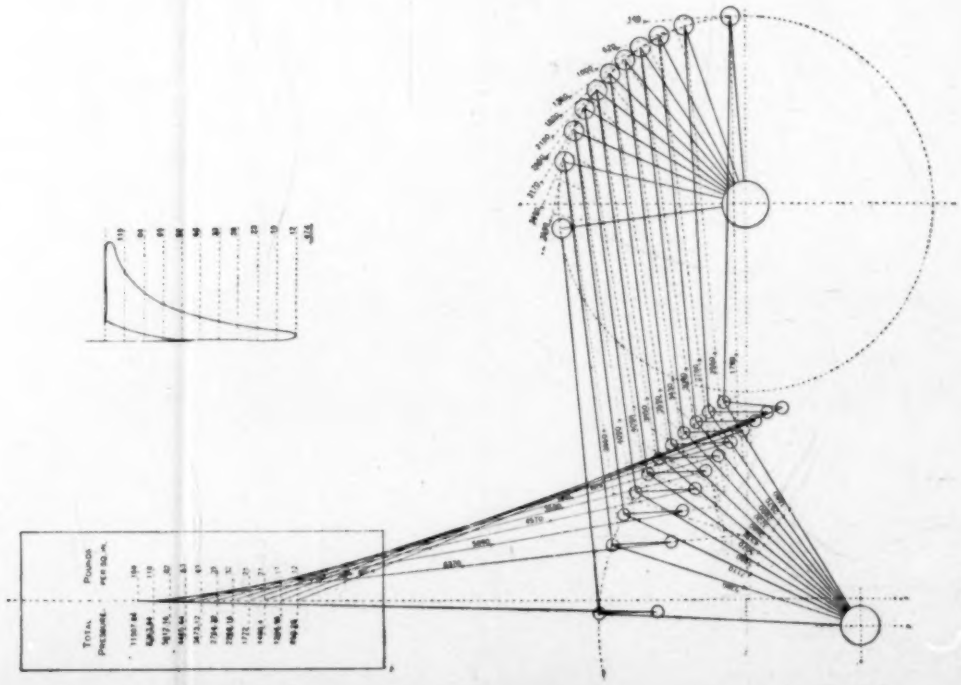


Fig. 25.—Force Distribution in Atkinson's Gas Engine.

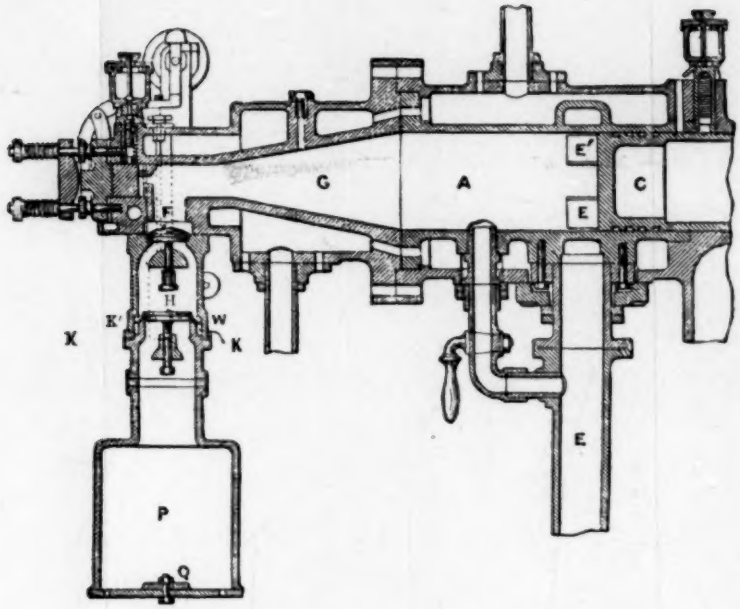


Fig. 22.—Vertical Section. Clerk, 1881.

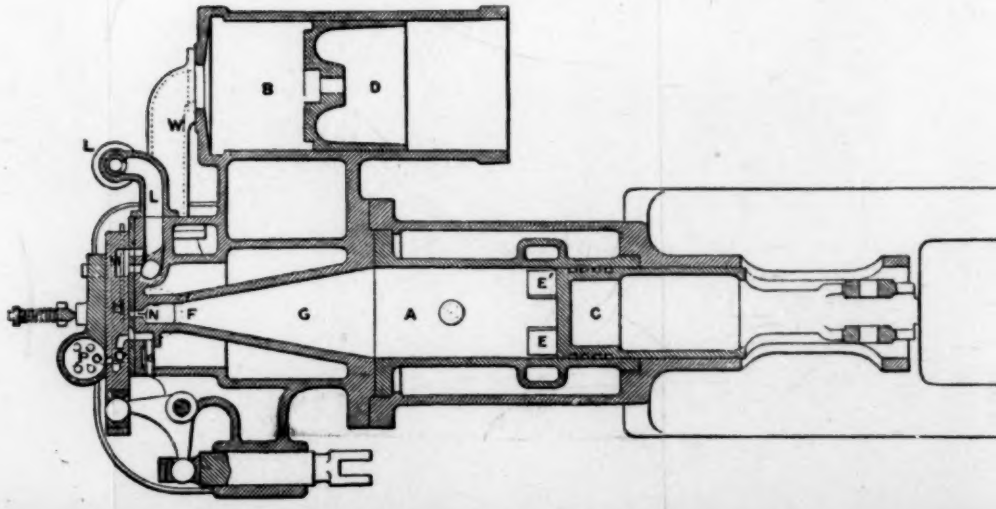


Fig. 21.—Sectional Plan. Clerk, 1881.

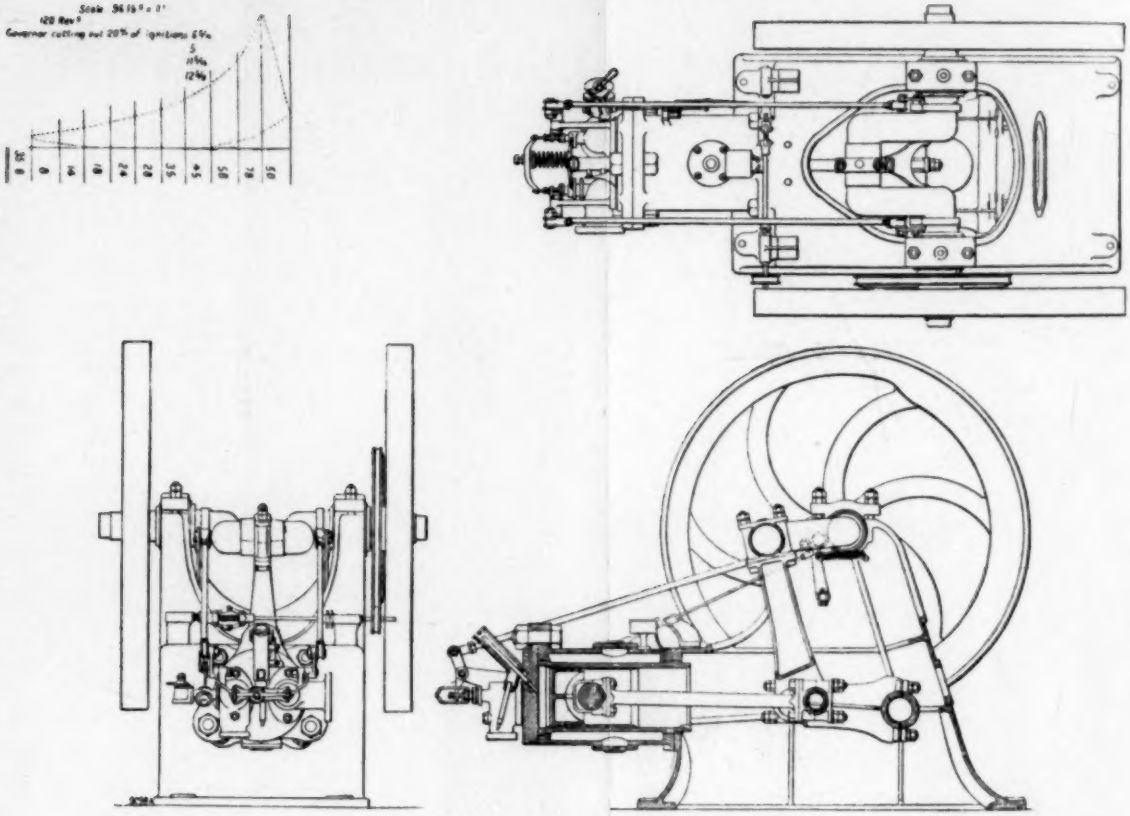


Fig. 23.—Atkinson, 1886. Section Plan, Rear Elevation and Indicator Diagram.

Fig. 20.—Clerk's Gas Engine 1881.

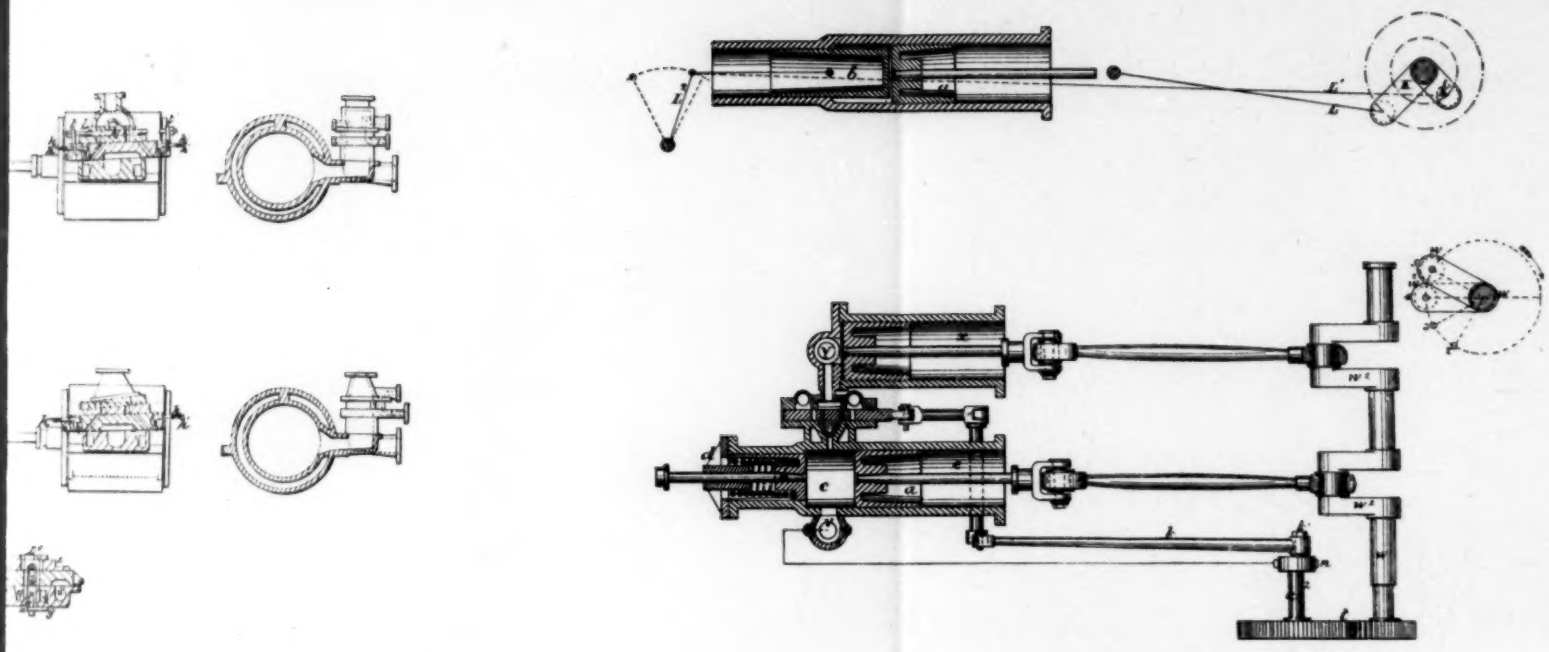


Fig. 19.—Otto Silent, 1881.

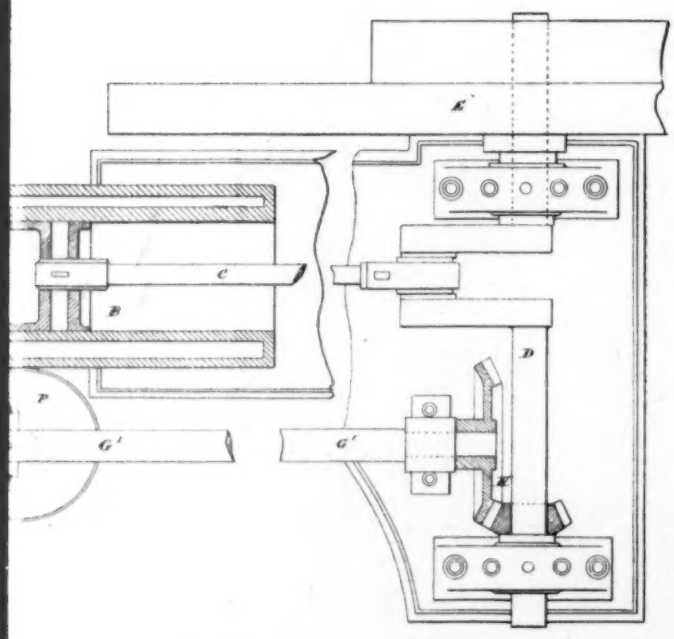


Fig. 17.—Otto-Crossley, 1877.

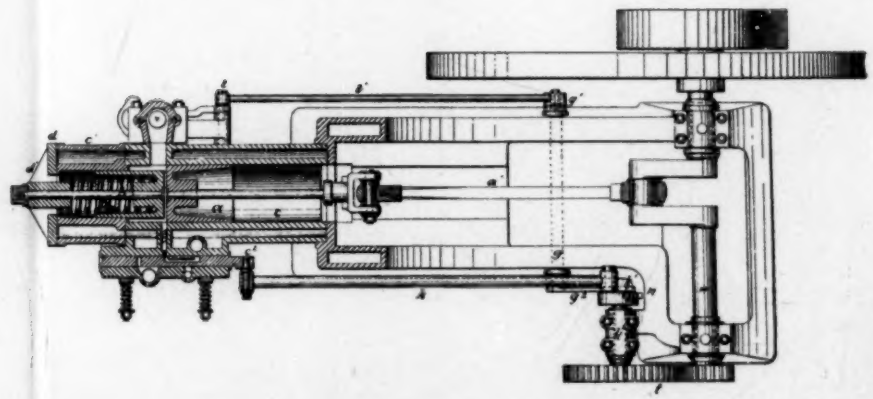


Fig. 18. Otto Silent, 1881.

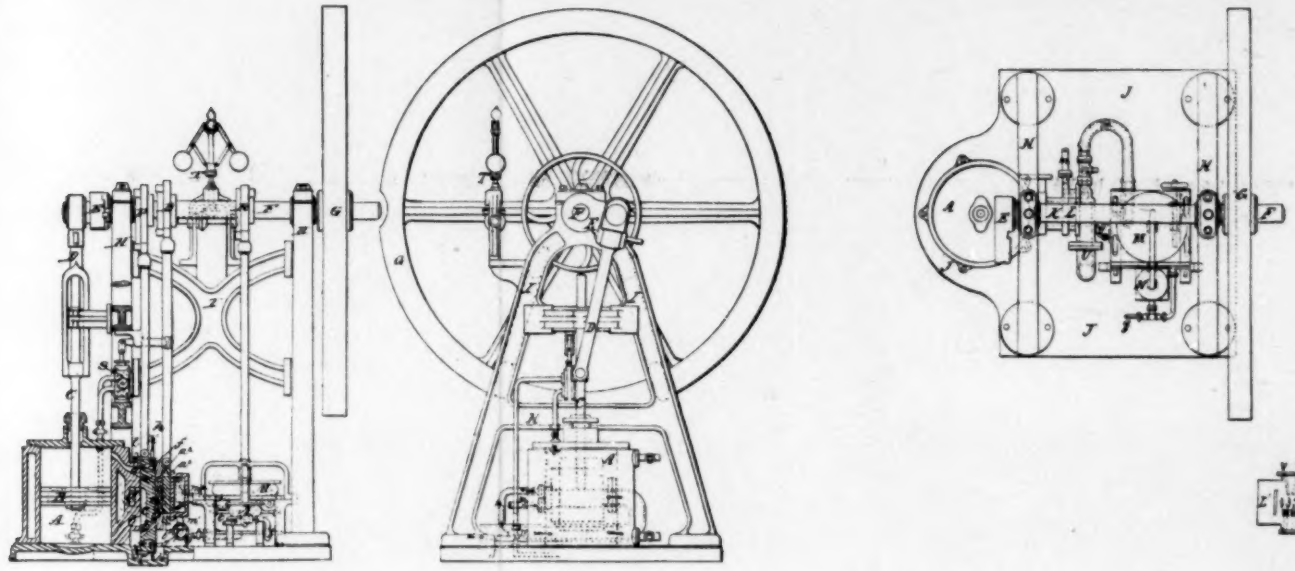


Fig. 15.—Hugon, 1865.

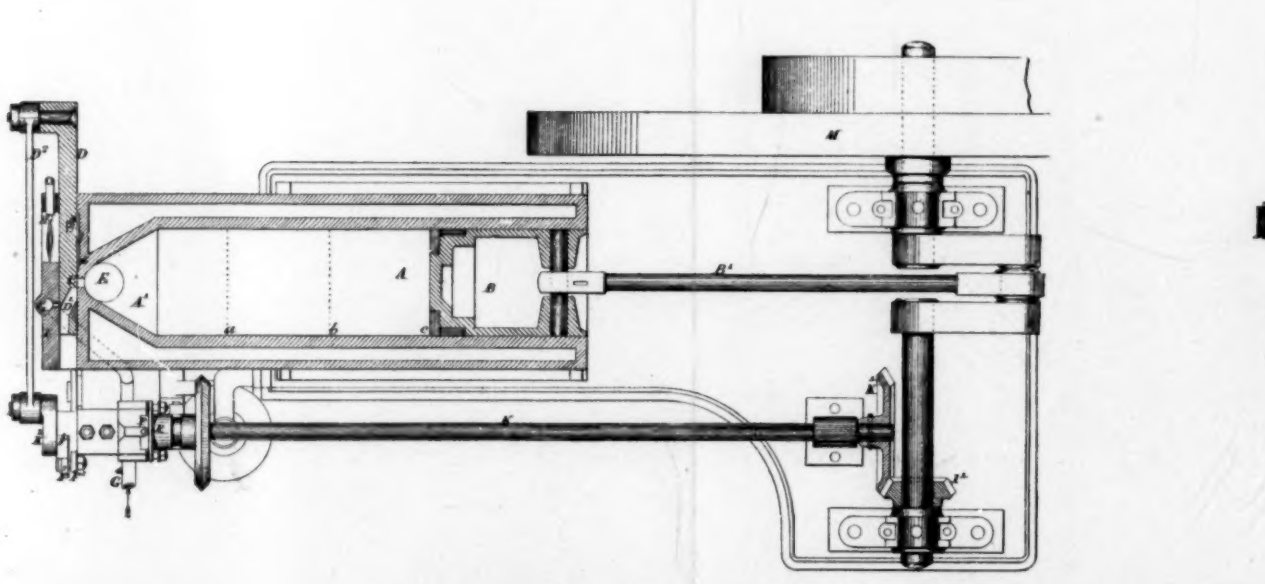


Fig. 16.—Otto Silent Gas Engine, 1877.

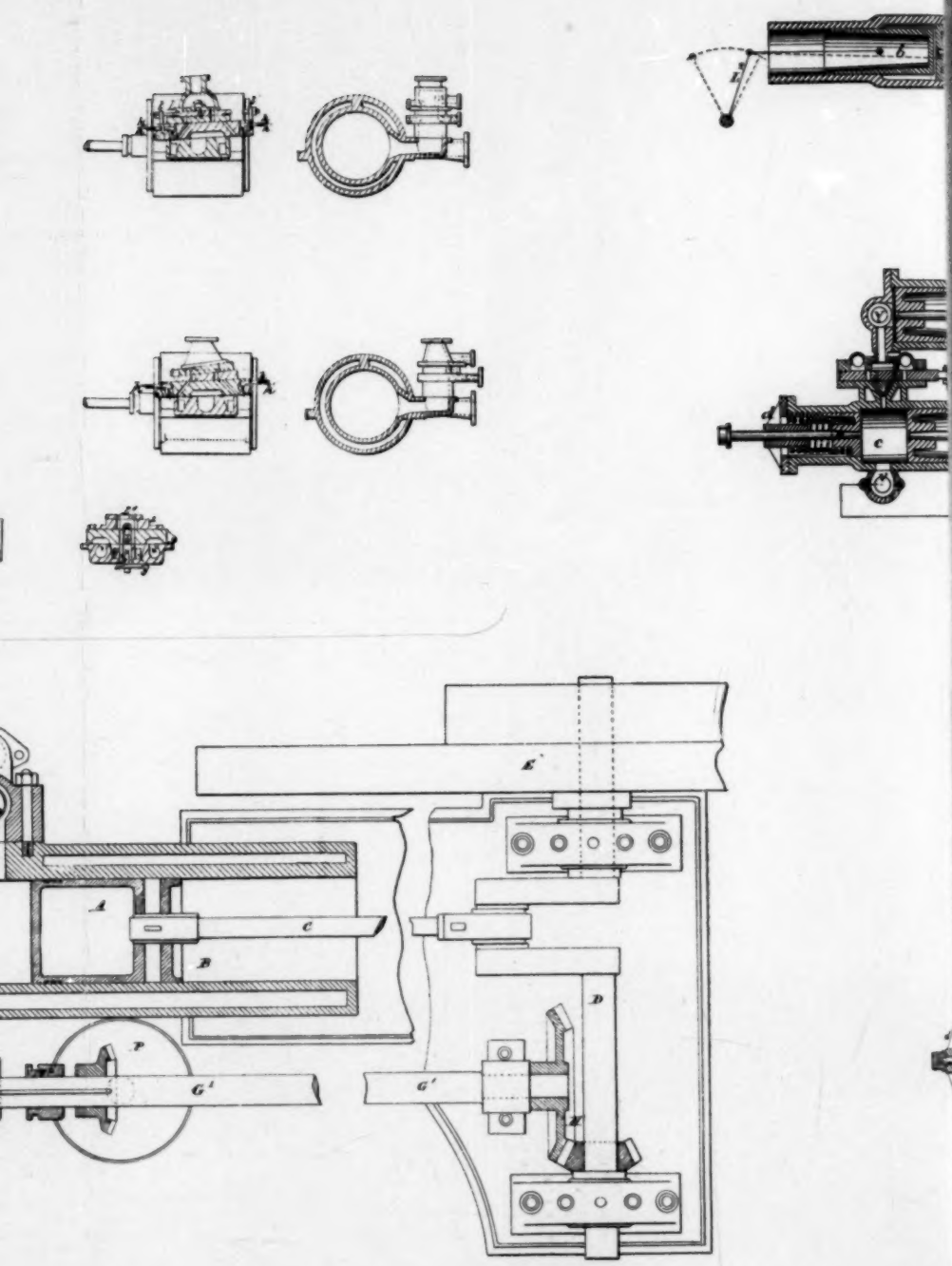


Fig. 17.—Otto-Crossley, 1877.

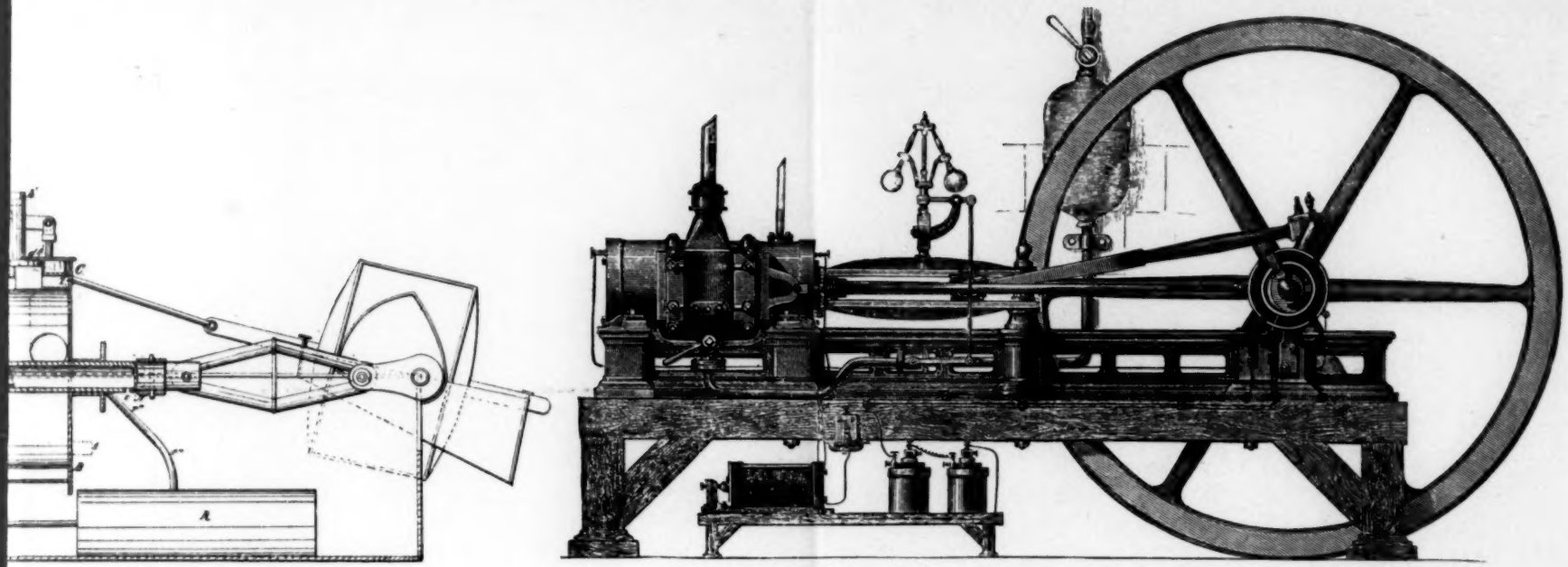


Fig. 11.—Lenoir's Gas Engine, 1860.

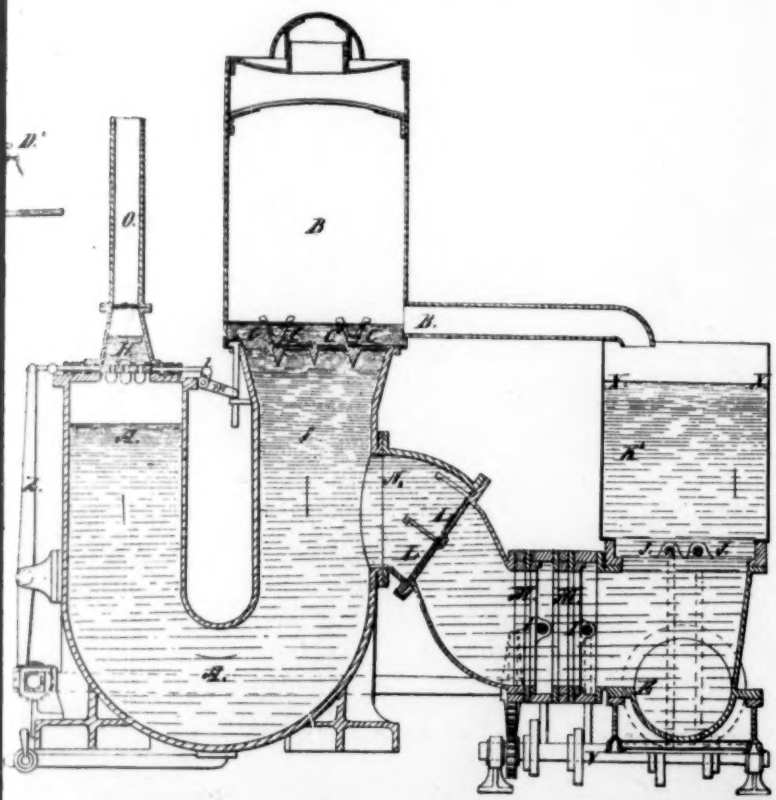


Fig. 13.—Hugon, 1864.

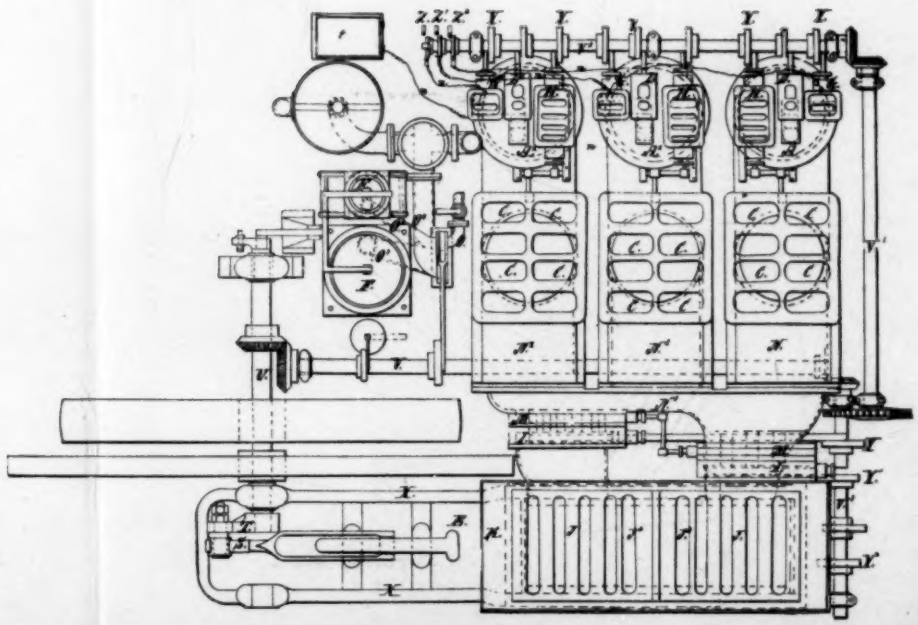


Fig. 14.—Hugon, 1864.

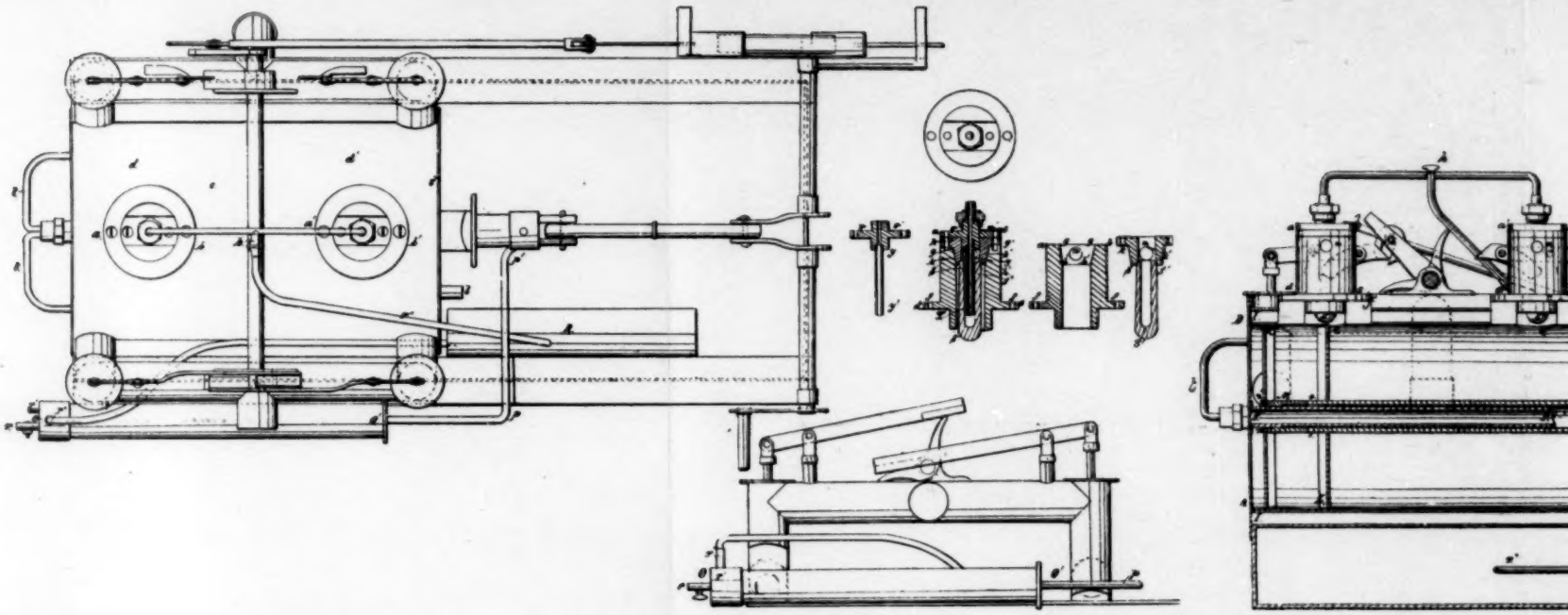
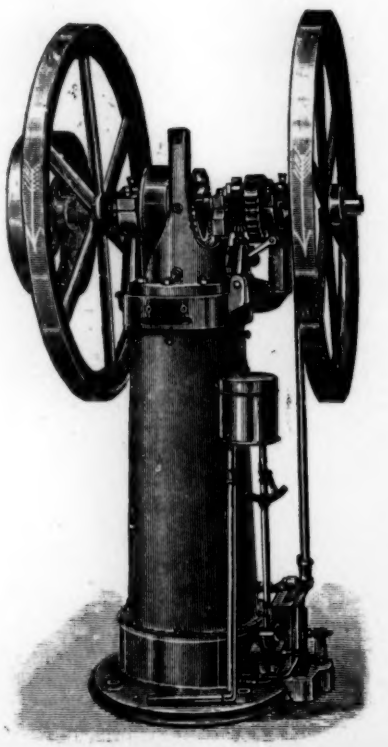
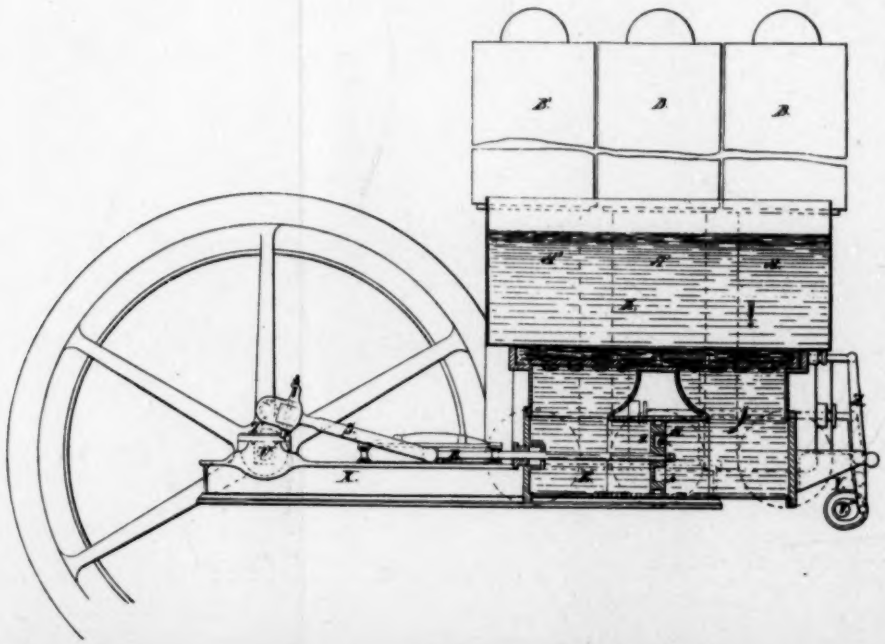


Fig. 8.—Drake's Gas Engine, 1855.





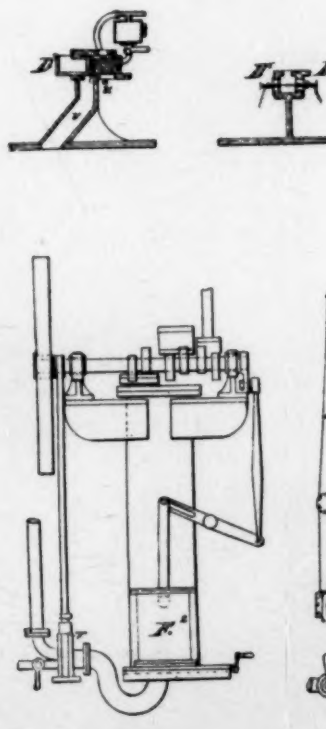


Fig. 13.—Hugon Gas Engine, 1864.

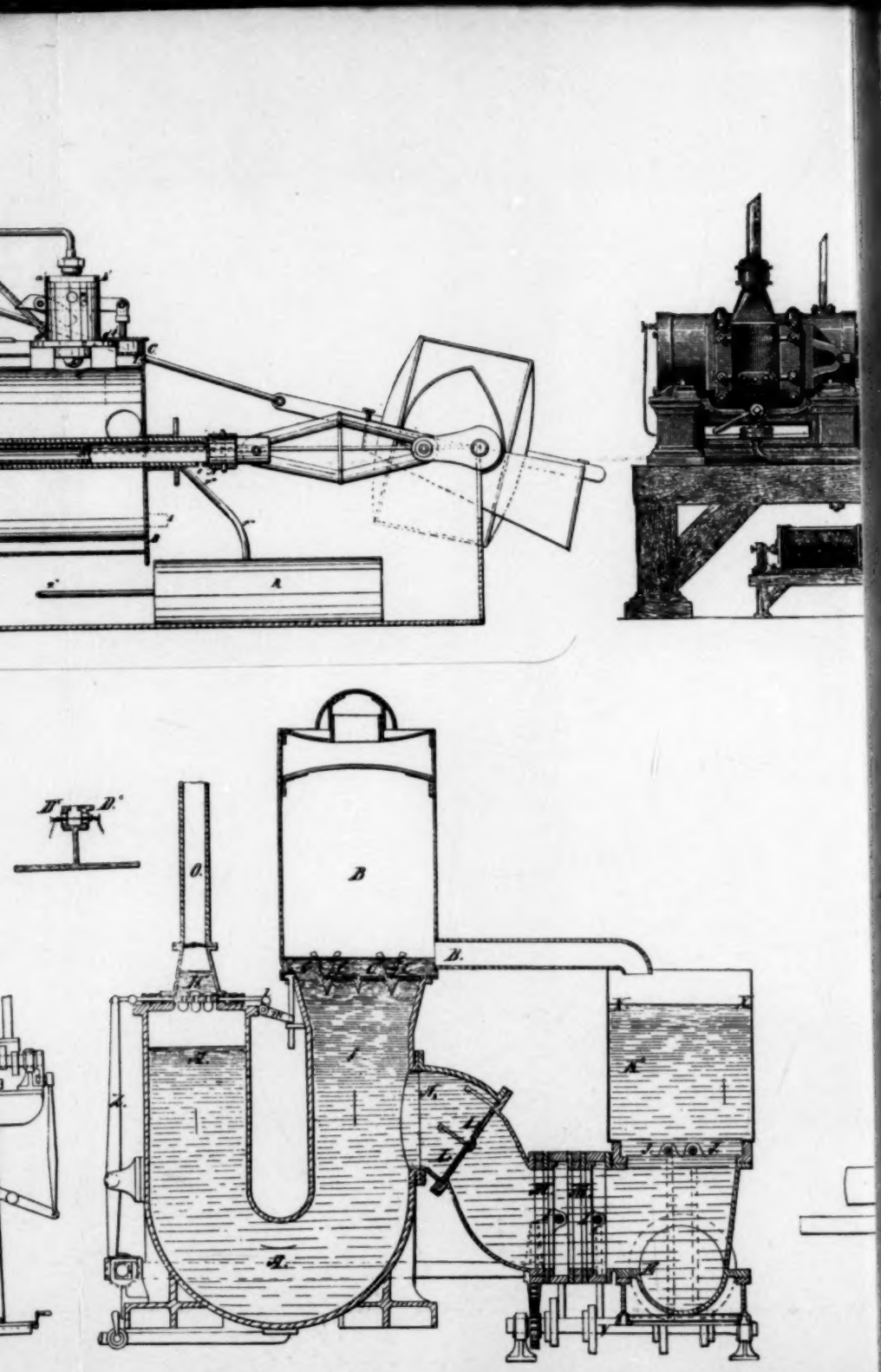


Fig. 13.—Hugon, 1864.